9

Options for Meeting Future Water Needs in Eastern Sierra and Colorado River Regions of California

This chapter covers the North and South Lahontan Hydrologic Regions in the eastern Sierra, and the Colorado River Hydrologic Region (Figure 9-1). These sparsely populated regions constitute 33 percent of the State's land area.

FIGURE 9-1
Eastern Sierra and Colorado River Hydrologic Regions

USBR's Parker Dam on the Colorado River.

FIGURE 9-2

North Lahontan Hydrologic Region

North Lahontan Hydrologic Region

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Description of the Area

The North Lahontan Region has two planning subareas (Figure 9-2), the Lassen Group and the Alpine Group. The Lassen Group PSA consists of Lassen and Modoc Counties. This high desert area is arid, with relatively flat valley areas adjacent to mountains. Valley elevations are about 4,000 and 4,500 feet for Honey Lake and Surprise Valleys. The Warner Mountains, which form the western boundary of Surprise Valley, range in elevation from about 7,000 to more than 9,000 feet. Annual precipitation ranges from as little as 4 inches in Surprise Valley in Modoc County to over 50 inches in the mountains of the Susan River watershed in Lassen County. The Alpine Group PSA includes parts of Sierra, Nevada, Placer, El Dorado, Alpine, and Mono Counties. The subarea includes the Truckee, Carson, and Walker River drainages. These rivers originate at high elevations on the eastern slopes of the Sierras and flow to terminal lakes or desert sinks in Nevada. Annual precipitation ranges from 8 inches in the valleys to more than 70 inches in the Sierra (much of this amount is snow).

The Lassen Group PSA is rural and sparsely populated. The City of Susanville is the largest population center in the subarea. In the Alpine PSA, more than 90 percent of the population lives in the Lake Tahoe and Truckee areas. The City of South Lake Tahoe and Town of Truckee are the largest communities in the subarea. The Tahoe-Truckee region has many part-time residents and visitors during the summer and winter recreational seasons, reflecting the importance of tourism to the area. Tourism and related recreational opportunities are vital to the region's economy and to much of the region's service-sector employment.

Cattle ranching is the main agricultural land use in the Lassen Group PSA. Irrigated land acreage is small (less than 4 percent of the region's land area). Commercial crop production is limited because of the short growing season. Pasture and alfalfa are the dominant irrigated crops. About 75 percent of the region's irrigated land is in Modoc and Lassen Counties, and most of the remainder is in the Carson and Walker River Basins in Alpine and Mono Counties. Irrigated lands in the Carson and Walker River Basins are almost exclusively pasture at elevations above 5,000 feet. Most of the uplands areas are federally owned and managed as national forest lands. Table 9-1 shows population and crop acreage for the region.

TABLE 9-1

Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	84	161
2020	125	165

Water Demands and Supplies

The water budget for the North Lahontan Region is shown in Table 9-2. Agricultural water demands are generally met with local surface water supplies, when available. Throughout the northern portions of the region, runoff is typically scant and stream flow decreases rapidly after the snowpack melts in the higher elevations.

No major changes in North Lahontan Region water use are anticipated within the Bulletin's planning horizon. Irrigated agriculture is constrained by climate

A majority of the land in the North Lahontan Region is owned by the federal government, managed primarily by USFS and BLM. National forest lands provide habitat for many species of wildlife, including some of California's larger mammals.

and by economically available water supplies. A small amount of agricultural expansion is expected, but only in areas that can support minor additional groundwater development. Likewise, the modest need for additional municipal supplies can be met by expanding present surface systems or increasing groundwater use. Drought year shortages are caused by a reduction in surface water supplies for agriculture and an increase in unit crop irrigation requirements for pasture and alfalfa. No urban water shortages are forecast.

Most of Susanville's water supply comes from groundwater and from Cady and Bagwell Springs. The city has not experienced any water supply shortages nor does it expect any shortages within the next 20 years.

The Honey Lake Valley Groundwater Basin is an interstate groundwater basin. The California portion of the basin is about 45 miles long and 10 to 15 miles wide. Groundwater extracted from the basin is used mainly for irrigation. Groundwater use in the basin appears to be near the basin's perennial yield. A 1987 agreement among the Department, the State of Nevada, and USGS resulted in a study of the groundwater flow system in eastern Honey Lake Valley. Upon conclusion of the study in 1990, the Nevada State Engineer ruled that only about 13 taf could be safely transferred from Nevada's portion of the basin for proposed new water development for Washoe County in Nevada. The Nevada out-of-basin transfer project has not been implemented.

The 7,840-acre Honey Lake Wildlife Area is on the north edge of Honey Lake about 20 miles southeast of Susanville. The HLWA consists of intensively managed wetlands, cropped fields, and uplands adjacent to the 60,000-acre Honey Lake. It provides important habitat for migratory waterfowl, sandhill

TABLE 9-2

North Lahontan Region Water Budget (taf)[a]

	1995		*2020*	
	Average	***Drought***	***Average***	***Drought***
Water Use				
Urban	39	40	50	51
Agricultural	530	584	536	594
Environmental	374	256	374	256
Total	**942**	**880**	**960**	**901**
Supplies				
Surface Water	777	557	759	557
Groundwater	157	187	183	208
Recycled and Desalted	8	8	8	8
Total	**942**	**752**	**950**	**773**
Shortage	**0**	**128**	**10**	**128**

[a] Water use/supply totals and shortages may not sum due to rounding.

TABLE 9-3
Major Reservoirs in the Truckee River Basin in California

Reservoir	*Owner*	*Operator*	*Usable Storage (taf)*	*Construction Date*[a]	*Height (Feet)*	*Drainage Area (Square Miles)*
Tahoe	Sierra Pacific Power Company[b]	Truckee-Carson Irrigation District	744.6	1913	18	506
Donner	Sierra Pacific Power Company/ Truckee-Carson Irrigation Dist.	Sierra Pacific Power Company	9.5	1927	14	14
Martis Creek[c]	USACE	USACE	20.4	1971	113	40
Prosser Creek	USBR	USBR	29.8	1962	163	50
Independence	Sierra Pacific Power Company	Sierra Pacific Power Company	17.5	1939	31	8
Stampede	USBR	USBR	226.5	1970	239	136
Boca	USBR	Washoe County Water Conservation District	41.1	1937	116	172

[a] Date existing dam was completed.
[b] USBR manages the facilities under easement from Sierra Pacific Power Company.
[c] Flood control storage only.

cranes, and other birds migrating on the Pacific Flyway. During the irrigation season, most of HLWA's water supply comes from Willow Creek and its tributaries. HLWA has adjudicated water rights, administered by the Department, as established in the 1940 Susan River Decree. Groundwater at the refuge is used for crop irrigation, for maintaining wetlands water levels, and for domestic purposes.

The Truckee River originates above Lake Tahoe. The river's flow downstream from Tahoe City is controlled by a small dam on the lake's outlet. The river flows through northeastern California and northwestern Nevada and terminates in Pyramid Lake, located within the Pyramid Lake Indian Reservation in Nevada. Additional Truckee River Basin storage facilities are listed in Table 9-3.

Most of the water supply developed by Truckee River Basin reservoirs is used in Nevada to meet urban demands in the Reno/Sparks area, irrigation demands, and fish and wildlife requirements in the lower Truckee River in Nevada and in Pyramid Lake. On average, about one-third of the Truckee River's annual flow is diverted through the Truckee Canal in Nevada to irrigate land in the Carson Division of USBR's Newlands Project near Fallon, Nevada.

Truckee River operations have evolved in response to litigation, negotiation, court decrees, agreements, and legislation. The 1915 Truckee River General Electric Decree and the 1935 Truckee River Agreement form the basis of current river operations. The 1944 Orr Ditch Decree established individual water rights in Nevada and, by incorporating the Truckee River Agreement, provided criteria for operating the federal reservoirs to serve those rights.

Modification of Truckee River operations occurred when two Pyramid Lake fish species were listed under the ESA. Cui-ui, the Indian name for a species of sucker found only in Pyramid Lake, were listed as an endangered species in 1967. Lahontan cutthroat trout were initially listed as endangered in 1970 and were subsequently reclassified as threatened in 1975. USBR's Stampede Reservoir, constructed in 1970 to serve irrigation and municipal uses, is operated to provide water for these fish, as required by a 1982 federal court decision. Proposed changes in Truckee River operations are described in the following water management issues section.

In the Truckee Basin within California, the urban water use occurs in and around the Town of Truckee, and is supplied by Truckee Donner PUD. TDPUD is the largest purveyor in the basin, accounting for about half of the water delivered to commercial and residential customers; its supplies are derived from groundwater. The Martis Valley groundwater basin is the principal source of water supply. The areas of Northstar, Squaw Valley, and Glenshire use groundwater from smaller basins or from fractured rock sources. The developed area around Donner Lake is

USBR's Stampede Reservoir is the second largest reservoir in the Truckee River Basin. Lake Tahoe is the largest reservoir in the basin.

Courtesy of USBR

served by surface water. Future water demands in the Truckee Basin are not expected to exceed the interstate allocations contained in the Truckee-Carson-Pyramid Lake Water Rights Settlement Act (PL 101-618), which limits the basin's annual use to 32 taf.

On the California side of the Lake Tahoe Basin, South Tahoe PUD, Tahoe City PUD, and North Tahoe PUD account for most of the water delivered to urban users. Water is supplied from the lake and from groundwater sources. The interstate allocation for California's Lake Tahoe Basin in PL 101-618 would limit future water use in the basin to 23 taf of gross diversions, which represents the basin's estimated future water needs at its full development. Future development in the Lake Tahoe Basin is strictly limited by the bistate Tahoe Regional Planning Agency to protect the basin's environmental quality. In both the Truckee and Tahoe Basins, water use for snowmaking at the area's ski resorts has been addressed in the interstate allocations.

Urban development in the Carson and Walker River Basins is minimal and is clustered around the towns of Markleeville in Alpine County and Bridgeport in Mono County. More than 90 percent of the watershed on the California side is federally owned, primarily under the management of the Toiyabe National Forest. Groundwater is the source of supply for individual users and small community systems located in valley areas. In the upper watershed, communities may lack suitable sites to locate wells and therefore must depend on surface water sources. The Town of Markleeville depends on surface water and experienced a water shortage in 1989 when the stream that supplies the community went dry. Water had to be piped 4 miles from another creek to the town's treatment plant.

In the upper Carson River watershed, water is stored in several very small alpine reservoirs originally constructed to supply irrigation needs. Much of this water is still used for irrigation downstream in Nevada. The largest of the alpine reservoirs is Heenan Lake on Monitor Creek, tributary to the East Fork Carson River, with a capacity of nearly 3 taf. The Carson River supports a popular recreational trout fishery in the upper watershed. DFG has used Heenan Lake for raising Lahontan cutthroat trout to stock at other locations throughout the Sierra. DFG currently manages State-owned lands adjacent to Heenan Lake and has arranged to purchase water on an annual basis to maintain a minimum reservoir pool for fish rearing.

Two special-purpose reservoirs were constructed in the upper Carson watershed to receive treated wastewater effluent exported from South Tahoe PUD in the Lake Tahoe Basin. (Disposal of treated wastewater within the Lake Tahoe Basin was banned to help protect the lake's clarity.) Beginning in the 1960s, wastewater effluent was delivered to Indian Creek Reservoir for subsequent release to agricultural users as a supplemental irrigation supply. In 1989, exports (about 5 taf/yr) were redirected to Harvey Place Reservoir. Indian Creek Reservoir is now used for freshwater recreation.

In addition to several small reservoirs in the upper watershed, the Walker River watershed has two large reservoirs—Topaz Reservoir (an offstream storage facility on the West Walker) and Bridgeport Reservoir on the East Walker. Both of the large reservoirs were

built by Walker River Irrigation District to sustain summer irrigation flows in its service area downstream in Nevada. WRID holds California water rights to store 57.6 taf of West Walker water, plus 200 af of local inflow, in Topaz Reservoir. WRID can store up to 39.7 taf in Bridgeport Reservoir. SWRCB has established instream flow and minimum reservoir pool requirements at Bridgeport, in response to fish kills that occurred during the last drought. Both reservoirs are popular local recreational destinations.

Part of the East Fork Carson River—approximately 10 miles from the town of Markleeville to the California/Nevada state line—has been added to the California wild and scenic river system. On the West Walker River, approximately 37 river miles have also been given State designation. The designated reach is from Tower Lake at the headwaters downstream to the confluence with Rock Creek, and about 1 mile of Leavitt Creek.

As occurred in the Truckee River Basin, water right disputes in the Carson and Walker River Basins were settled with federal court decrees. The 1980 Alpine Decree on the Carson River and the 1936 Decree C-125 on the Walker River control most river operations. The decrees established surface water rights, including reservoir storage rights, of water users in both California and Nevada. However, the decrees only quantify individual water rights of parties to the litigation and did not address rights perfected under state law by others—not all existing water uses are necessarily covered in the decrees. PL 101-618 established an interstate allocation in the Carson River Basin; the California allocation corresponds to existing water uses.

Local Water Resources Management Issues

Truckee River Operating Agreement

Negotiation of a proposed Truckee River Operating Agreement and preparation of its draft EIR/EIS have been the major water management activities in the region. A new operating agreement for the Truckee River is required by PL 101-618. Negotiation of a proposed TROA and preparation of an EIR/EIS for the TROA began in 1991. The draft EIR/EIS was released for public review in 1998 and is expected to be completed in 1999.

PL 101-618 settled years of disputes over Truckee and Carson River waters by making an interstate allocation between California and Nevada. It also settled certain tribal water right claims and provided for water supplies for specified environmental purposes in Nevada. The act allocated 23 taf annually to California in the Lake Tahoe Basin and 32 taf annually in the Truckee River Basin below Lake Tahoe. The act allocated water corresponding to existing Carson River Basin water uses to California. The remainder of the

USBR's Prosser Creek Reservoir is one of the Truckee River system reservoirs whose operation would be covered by the TROA.

Truckee and Carson River supply was allocated to Nevada.

When executed, the TROA would establish river operations procedures to meet water rights on the Truckee River and to enhance spawning flows in the lower Truckee River for cui-ui and Lahontan cutthroat trout. TROA would provide for management of water within the Truckee Basin in California, including instream flow requirements and reservoir storage for fishery and recreation uses, and would include procedures for coordinating releases and exchanges of water among the watershed's reservoirs. TROA would become the exclusive federal regulation governing releases of water stored in Lake Tahoe, Martis Creek, Prosser Creek, Stampede, and Boca Reservoirs. The agreement would provide an accounting procedure for surface and groundwater diversions in California's part of the Truckee Basin and would establish criteria to minimize short-term reductions in river flow potentially caused by future well construction near the river.

In 1993, an agreement was signed by Sierra Pacific Power Company, Washoe County Water Conservation District, and Sierra Valley Water Company settling a dispute about when the water company was required to stop diverting water from the Little Truckee River. This agreement, which resolves disputes that had often occurred during droughts, is being incorporated into the proposed TROA.

Walker River

Recent activities in the Walker River Basin have focused on the declining level of Walker Lake in Nevada and the resulting impact on the lake's fishery. Because Walker Lake is a terminal sink, salts accumulate as the lake water evaporates. Declining lake levels have resulted in most Great Basin terminal sinks being too saline to support fisheries. Walker Lake is one of three terminal lakes in Nevada that support fish life. The water level at Walker Lake has declined from an elevation of about 4,080 feet in 1882 to 3,944 feet in 1994; salinity has increased during the same period from about 2,500 mg/L TDS to 13,300 mg/L TDS.

In most years, Walker River is the primary source of inflow to Walker Lake. Flow in the river comes from runoff in the Sierra in California. Upstream agricultural diversions have contributed to reduced inflows, resulting in a declining lake level and increased lake salinity. If the trend continues, the Lahontan cutthroat and the tui chub (an important food source for the trout) may not be able to survive in the lake. To maintain lake salinity at the current level, about 33 taf/yr more inflow is needed. Even with a stable lake level, salinity will slowly increase because Walker Lake has no natural outlet. A solution to Walker Lake problems could affect water users in California and Nevada. Potential tribal water rights claims on the Nevada side of the basin could also affect existing water users.

Lake Tahoe

Lake Tahoe's clarity has been declining as increasing development around the shoreline increases the sediment load and nutrients reaching the lake. Nutrients, such as nitrogen and phosphorous used in lawn or golf course fertilizers, can enter the lake in the form of storm water runoff. Nutrients promote growth of algae, reducing clarity. Clarity of lakes is measured by the depth to which a Secchi disk, a small plastic disk of specific size, is visible. In the late 1960s, average Secchi disk visibility in Lake Tahoe was about 100 feet. Now the figure is closer to 70 feet.

Programs to manage Lake Tahoe water quality by regulating development and preventing pollutants from reaching the lake are being implemented at the federal, state, and local levels. The Tahoe Regional Planning Agency, a bistate agency created by Congress, sets regional environmental standards, issues land use permits (including conditions to protect water quality), and takes enforcement actions throughout the basin. TRPA's regional plan provides for achievement and maintenance of environmental targets by managing growth and development. In addition to its regulatory activities, TRPA carries out a capital improvement program to repair environmental damage done before its regional plan was adopted. TRPA has identified nearly $500 million in capital improvements needed to achieve environmental targets. Federal, state, and local governments have invested nearly $90 million in erosion control, storm water drainage, stream zone restoration, public transit, and other capital projects. Over 70 percent of the land in the Tahoe Basin is controlled by the USFS's Lake Tahoe Basin Management Unit. The LTBMU has implemented a watershed restoration program and a land acquisition program to prevent development of sensitive private lands.

In recent years, federal and state agencies have increased funding to protect the environment of Lake Tahoe. The State of Nevada approved a $20 million

bond measure to perform erosion control and other measures on the east side of the lake. In California, Proposition 204 provides $10 million in bond funds for land acquisition and programs to control soil erosion, restore watersheds, and preserve environmentally sensitive lands.

Leviathan Mine

Leviathan Mine, an abandoned sulfur mine located in Alpine County, is one of the most significant abandoned mine sites in the region. From 1863 to 1952, operations at the site involved tunnel mining. Later, the site was converted to an open-pit operation. Under this operation, tailings and overburden material were placed in (or washed into) streams, creating water pollution problems with acid mine drainage and metals. The mine was ultimately abandoned, leaving an open pit, waste and spoil areas, and surface water drainage and erosion problems. Neither the owner nor the county had the resources to clean up the site.

In 1980, SWRCB approved a pollution abatement project for Leviathan Mine. The remediation project included channeling Leviathan Creek, filling and regrading the mine pit, excavating and regrading the waste dump, creating onsite evaporation ponds, regrading the spoil areas, and improving drainage. The State acquired the site in 1983 and the project was completed in 1985. Although the project reduced the amount of acid mine drainage reaching the creek, contamination problems still occur today from pond overflows, acidic springs, seepage, and erosion. The RWQCB is currently involved in activities to further reduce the pollution.

Sierra Nevada Ecosystem Project

The Sierra Nevada Ecosystem Project was an assessment of forests, key watersheds, and significant natural areas on federal lands. In 1996, the University of California released its *Sierra Nevada Ecosystem Study*, the result of a three year, congressionally-mandated study of the entire Sierra Nevada, with primary emphasis on gathering and analyzing data to assist Congress in future management of the mountain range. The study stated that "excluding the hard-to-quantify public good value of flood control and reservoir-based recreation, the hydroelectric generating, irrigation, and urban use values of water are far greater than the combined value of all other commodities produced in the Sierra Nevada." The report estimated the value of water at 60 percent of that of all commodities produced in the foothills and mountains of the Sierra Nevada.

January 1997 Flood Event

The January 1997 flood was among the most significant floods on record in the North Lahontan Region. Lake Tahoe recorded its highest level since 1917 at an elevation of 6,229.39 feet. This elevation was the lake's highest since the 1935 Truckee River Agreement, which limited the operating range of Lake Tahoe's surface elevation to between 6,223.0 feet (its natural rim) and 6,229.1 feet. Flood damage occurred along the Truckee's channel immediately downstream from the lake, although the greatest economic damages occurred in the Reno-Sparks area. In California, flooding in downtown Truckee caused the closure of major highways. Downstream from Truckee, the river washed away Floriston Dam, a diversion dam used by Sierra Pacific Power Company to divert water to its run-of-river hydroelectric plant at Farad.

Stream flows along the Carson and Walker River systems exceeded previous flood records. Flows along the East Fork Carson River at Markleeville and West Fork Carson River at Woodfords peaked at 21,000 cfs and 8,000 cfs, respectively, considerably above the record peak flows attained in 1963 and in excess of a 100-year flood event for these reaches of the river. The East Walker River near Bridgeport and West Walker River near Coleville peaked at 1,810 cfs and 6,220 cfs, respectively, also above previously record flows. In Mono County, about 8 miles of U.S. Highway 395 were washed out, isolating the communities of Coleville and Walker. At the lower mouth of the Walker Canyon, homes and properties in the community of Walker were damaged when the West Walker River spilled its banks.

Water Management Options for the North Lahontan Region

Table 9-4 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 9A-1 in Appendix 9A) based on a set of fixed criteria discussed in Chapter 6. Potential options to augment water supplies during drought conditions are water conservation, groundwater pumping, and reservoir construction. Land is idled during droughts if water is not available. In Mono County, cutbacks in surface water deliveries

TABLE 9-4

North Lahontan Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to 0.8 ETo	Retain	
Indoor Water Use	Retain	
Interior CII Water Use	Defer	No significant depletion reductions attainable.
Distribution System Losses	Defer	No significant depletion reductions attainable.
Agricultural		
Seasonal Application Efficiency Improvements	Defer	No significant depletion reductions attainable.
Flexible Water Delivery	Defer	No significant depletion reductions attainable.
Canal Lining and Piping	Defer	No significant depletion reductions attainable.
Tailwater Recovery	Defer	No significant depletion reductions attainable.
Modifying Existing Reservoirs/Operations		
—	—	—
New Reservoirs/Conveyance Facilities		
Petes Valley Reservoir	Defer	High costs.
Willard Creek Reservoir	Defer	High costs.
Goat Mountain Reservoir	Defer	High costs.
Crazy Harry Gulch Reservoir	Defer	High costs.
Honey Lake Dike and Reservoir	Defer	Water quality inadequate for agriculture. Very low yields with large estimated capital costs.
Long Valley Creek Reservoir	Defer	Very little firm yield.
Hope Valley Reservoir	Defer	High costs.
Leavitt Meadows Reservoir	Defer	Site is located on the West Walker River, upstream of a reach designated as wild and scenic. Also subject to interstate water issues with Nevada.
Pickle Meadow Reservoir	Defer	Same concerns as Leavitt Meadows site.
Roolane Reservoir	Defer	Same concerns as Leavitt Meadows site.
Mountain Lakes Reservoir	Defer	Same concerns as Leavitt Meadows site.
Groundwater/Conjunctive Use		
Agricultural Groundwater Development	Retain	
Eastside Warner Mountain Recharge	Defer	DFG concerns about potential wildlife impacts have diminished local interest in a pilot program and/or reconnaissance level planning study.
Water Marketing		
—	—	—
Water Recycling		
Water recycling options	Defer	Water recycling options would not generate new water supply in this region.

TABLE 9-4
North Lahontan Region List of Water Management Options (continued)

Option	*Retain or Defer*	*Reason for Deferral*
Desalting		
Brackish Groundwater		
—	—	—
Seawater		
—	—	—
Other Local Options		
—	—	—
Statewide Options		
—	—	—

during the recent drought resulted in pasture not being irrigated.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. Urban conservation options in this region provide little potential for depletion reductions. Reducing outdoor water use to 0.8 ET_o in new and existing development would only conserve about 1 taf/yr. Likewise, reducing indoor water use to 55 gpcd would conserve about 1 taf/yr.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. The efficiency of border irrigation systems used for alfalfa and pasture can be improved through leveling fields and better managing applications. No significant depletion reductions are expected in the region, however, since most alfalfa irrigation occurs in Honey Lake Valley where excess applied irrigation water recharges the groundwater basin.

New Reservoirs or Conveyance Facilities

In 1992, the Department investigated six potential reservoir sites in Lassen County that could provide up to 20 taf of storage. Sites were located on the Susan River, Willow Creek, and Long Valley Creek. An analysis of project costs indicates that the reservoirs were not economically feasible for agricultural water users in the region.

In the late 1950s and early 1960s, the Department examined potential reservoir sites in Mono County that could serve agricultural lands in California. USBR, USGS, NRCS, and WRID have studied these and other potential sites in California that could provide water for Nevada uses. Projects that serve Nevada only are not included as options. The four potential sites in Mono County located on the West Walker River have similar economic constraints as the sites in Lassen County. They are also subject to interstate water rights concerns.

Groundwater Development or Conjunctive Use

Although groundwater is available in the larger valleys used for irrigated agriculture, water needs are usually met from surface water. Groundwater cannot be economically used to replace surface water uses because of pumping costs.

Modoc County Resource Conservation District investigated groundwater recharge on six creeks which drain the east slopes of the Warner Mountains in Surprise Valley. This project would recharge the alluvial fans using existing stream channels or constructed recharge facilities. Experimental construction of recharge areas on one or two of the creeks was proposed, but potential environmental impacts and lack of funding prevented implementation. This option was deferred.

Options Likely to be Implemented in the North Lahontan Region

Water supplies are not available to meet all of the region's 2020 water demands in average or drought years. Applied water shortages are forecasted to be 10 taf and 128 taf in average and drought years, respectively. Ranking of retained water management options for the North Lahontan Region is summarized in Table 9-5. Table 9-6 summarizes options that can likely be implemented by 2020 to relieve the shortages.

Although groundwater could be developed to help meet drought year water needs, it is not ranked highly due to its cost. During droughts, pasture irrigation will probably continue to be curtailed.

TABLE 9-5

Options Ranking for North Lahontan Region

Option	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Urban				
Outdoor Water Use to 0.8 ET_o – New and Existing Development	M	[a]	1	1
Indoor Water Use (55 gpcd)	M	600	1	1
Groundwater/Conjunctive Use				
Agricultural Groundwater Development	M	[a]	[a]	[a]

[a] Data not available to quantify.

TABLE 9-6

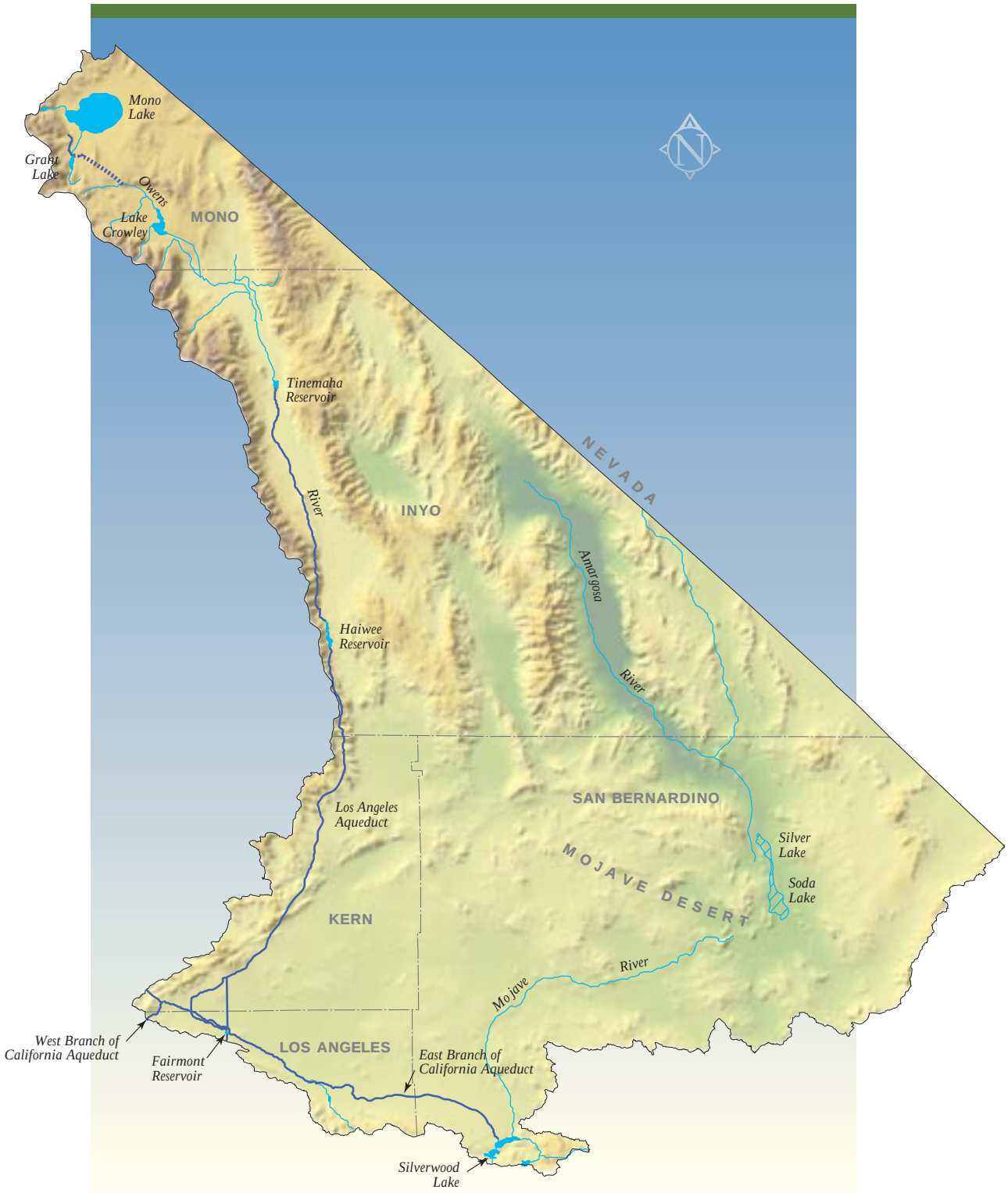
Options Most Likely to be Implemented by 2020 (taf)
North Lahontan Region

	Average	*Drought*
Applied Water Shortage[a]	**10**	**128**
Options Likely to be Implemented by 2020		
Conservation	—	—
Modify Existing Reservoirs/Operations	—	—
New Reservoirs/Conveyance Facilities	—	—
Groundwater/Conjunctive Use	—	—
Water Marketing	—	—
Recycling	—	—
Desalting	—	—
Other Local Options	—	—
Statewide Options	—	—
Expected Reapplication	—	—
Remaining Applied Water Shortage	**10**	**128**

[a] Majority of shortages in this region are agricultural.

FIGURE 9-3

South Lahontan Hydrologic Region



South Lahontan Hydrologic Region

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Description of the Area

The South Lahontan Region encompasses the area from the drainage divide between the Walker River and Mono Lake Basin to the divide south of the Mojave River (Figure 9-3). The region is bordered on the east by the Nevada stateline and on the west by the crest of the southern Sierra Nevada and San Gabriel Mountains. The region includes all of Inyo County and parts of Mono, San Bernardino, Kern, and Los Angeles Counties. Prominent geographic features of the region are Owens Valley and Death Valley. The region contains the highest and lowest points in the lower 48 states—Mount Whitney (elevation 14,495 feet) and Death Valley (elevation 282 feet below mean sea level).

The region includes several closed drainage basins and many desert valleys containing central playas, or dry lakes. Major waterbodies in the region are, from north to south, Mono Lake, Owens River, and Mojave River. The Amargosa River contains water only during rare flash floods. Floodwaters in the Amargosa River would eventually flow south to a sink area at the Silver Lake and Soda Lake Playas. This sink area is also the terminus of the Mojave River, which flows eastward from its headwaters in the San Bernardino Mountains across the Mojave Desert to the playa lakes. Average annual precipitation for the region's valleys ranges between 4 and 10 inches. Death Valley receives only 1.9 inches annually. The Sierra Nevada can receive up to 50 inches annually, much of it in the form of snow. In some years, the community of Mammoth Lakes can have snow accumulations of more than 10 feet.

The Joshua Tree, a member of the yucca family, is endemic to the Mojave Desert.

Although sparsely populated, the region contains some rapidly growing urban areas, including the Cities of Lancaster and Palmdale in Antelope Valley (Los Angeles County) and the Cities of Victorville, Hesperia, and Apple Valley in San Bernardino County. Many residents in these areas have chosen a long commute to the greater Los Angeles area in exchange for affordable housing. Future population growth in the region is expected to be concentrated in communities within commuting distance of the Los Angeles area. Bishop, Ridgecrest, and Barstow are other population centers in the region. The economies of these and other small towns in the eastern part of the region are tied to the region's military facilities and other governmental employers, and to providing services for travelers and tourists.

Public lands constitute about 75 percent of the region's area, providing a major recreational resource. Popular destinations in the region include the Mono Lake area, June Lakes and Mammoth Lakes, Inyo National Forest, Death Valley National Monument, and the recently created Mojave National Preserve. Only about 1 percent of the region's land is used for urban and agricultural purposes. Most of the irrigated acreage, primarily alfalfa and pasture, is in the Mono-Owens PSA. (This PSA includes Owens Valley, the Lake Crowley area northwest of Bishop, and Hammil and Fish Lake Valleys.) Some deciduous orchard acreage is found in the western part of the region. Table 9-7 shows population and crop acreage for the region.

The Owens River, with the Sierra Nevada in the background.

TABLE 9-7

Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	713	61
2020	2,019	45

Major perennial waterbodies in the region are Mono Lake and Owens River. Since relatively little surface water is available in the rest of the region, the region's environmental water use is concentrated in the Mono Lake-Owens Valley corridor. The major environmental water use requirements are associated with maintenance of Mono Lake levels and fishery instream flow requirements for the Owens River system. DFG operates four fish hatcheries in the Mono-Owens area: Mt. Whitney, Big Springs, Hot Creek, and Black Rock Hatcheries.

The largest surface water development in the region is the Los Angeles Aqueduct and its associated facilities, described in the following section. There are also a few relatively small, high-elevation dams operated by Southern California Edison for nonconsumptive hydropower purposes. These dams do not provide water supply for the region. SWP's 75 taf Lake Silverwood on the East Branch of the California Aqueduct regulates and stores imported water.

Water Demands and Supplies

The water budget for the South Lahontan Region is shown in Table 9-8. Increased environmental water demands from recently settled court actions involving LADWP's water diversions from the Owens Valley and Mono Lake are reflected in the base water budget. A pending order issued by an air pollution control district in 1997 could increase environmental water demands in the region. This increase is not included in the water budget because final action has not yet been taken (see the local water resources management issues section).

Los Angeles Aqueduct

The Los Angeles Aqueduct is the region's major water development feature, although it does not serve water to the region. In 1913, the first pipeline of LAA was completed and began conveying water from Owens Valley to the City of Los Angeles. The aqueduct was extended north of the Mono Basin and diversions be-

TABLE 9-8
South Lahontan Region Water Budget (taf)[a]

	1995		*2020*	
	Average	***Drought***	***Average***	***Drought***
Water Use				
Urban	238	238	619	619
Agricultural	332	332	257	257
Environmental	107	81	107	81
Total	**676**	**651**	**983**	**957**
Supplies				
Surface Water	322	259	437	326
Groundwater	239	273	248	296
Recycled and Desalted	27	27	27	27
Total	**587**	**559**	**712**	**649**
Shortage	**89**	**92**	**270**	**308**

[a] Water use/supply totals and shortages may not sum due to rounding.

gan in 1940. A second pipeline was completed in 1970, increasing the aqueduct's annual delivery capacity to about 550 taf/yr. Both aqueducts terminate at the 10 taf Los Angeles Reservoir in the South Coast Region. The first aqueduct begins at the intake on Lee Vining Creek and the second begins at Haiwee Reservoir.

There are eight reservoirs in the LAA system with a combined storage capacity of about 323 taf (Table 9-9). These reservoirs were constructed to store and regulate flows in the aqueduct. The northernmost reservoir is Grant Lake in Mono County. Six of the eight reservoirs are located in the South Lahontan Region. Bouquet and Los Angeles Reservoirs are in the South Coast Region.

Water from both aqueducts passes through 12 powerplants on its way to Los Angeles. The annual energy generated is over 1 billion kWh, enough to supply the needs of 220,000 homes.

TABLE 9-9
Los Angeles Aqueduct System Reservoirs

Reservoir	***Capacity (taf)***	***County***
Grant	47	Mono
Crowley	183	Mono
Pleasant Valley	3	Inyo
Tinemaha	6	Inyo
Haiwee	39	Inyo
Fairmont	0.5	Los Angeles
Bouquet	34	Los Angeles
Los Angeles	10	Los Angeles

State Water Project

The East Branch of the California Aqueduct follows the northern edge of the San Gabriel Mountains, bringing imported water to Silverwood Lake. Table 9-10 shows SWP contractors in the region and their contractual entitlements.

Antelope Valley-East Kern Water Agency, the largest SWP contractor in the region, serves 5 major and 16 small municipal agencies, as well as Edwards AFB, Palmdale Air Force Plant 42, and U.S. Borax and Chemical Facilities. AVEK was formed to bring imported water into the area.

Mojave Water Agency was created in 1960 in response to declining groundwater levels in the area. Communities within MWA's boundaries have no source of supply other than groundwater. Communi-

TABLE 9-10
SWP Contractors in the South Lahontan Region

Contractor	***Annual Entitlement (taf)***	***1995 Deliveries (taf)***
Antelope Valley-East Kern WA	138.4	47.3
Crestline-Lake Arrowhead WA	5.8	0.4
Littlerock Creek ID	2.3	0.5
Mojave WA	75.8	8.7
Palmdale WD	17.3	7.0

ties served by MWA include Barstow, Apple Valley, Hesperia, and Victorville. While most of MWA's service area is within the South Lahontan Region, the service area extends into the Colorado River Hydrologic Region (the Lucerne and Johnson Valleys and the Morongo Basin). Part of MWA's SWP entitlement (7.3 taf) is allocated to that area.

MWA has taken little of its SWP entitlement to date, due to lack of conveyance facilities. In 1994, MWA completed its Morongo Basin pipeline, a 71-mile pipeline with a capacity of 100 cfs from the SWP's East Branch to the Mojave River (7 miles) and then 20 cfs to Morongo Basin and Johnson Valley. This pipeline allows MWA to bring SWP water into part of its large (almost 5,000 square miles) service area. In 1997, MWA began construction of its 71-mile Mojave River Pipeline (94 cfs capacity) to bring imported water to Barstow and neighboring cities. The El Mirage Aqueduct is the next proposed addition to its distribution system. The aqueduct would deliver approximately 4 taf of imported water annually from the East Branch to the westernmost subarea of the Mojave River Basin near El Mirage. Imported water would be used to recharge the area's overdrafted groundwater basin.

In 1997, MWA and Berrenda Mesa Water District (a member agency of KCWA) concluded the permanent transfer of 25 taf of SWP annual entitlement, thereby increasing MWA's total annual entitlement to 75.8 taf.

Littlerock Reservoir is one of the few surface water storage facilities in the Mojave Desert area. The original dam at this site was a multi-arch concrete structure. This photo shows the dam after its seismic rehabilitation.

Local Surface Water Supplies

The Mammoth Community Water District supplies the town of Mammoth Lakes, located at the northern end of the region. About 70 percent of MCWD's supply comes from Lake Mary, the largest of a number of small alpine lakes in the Mono Lakes Basin. At present, the remainder of MCWD's supply comes from groundwater. Although MCWD serves a permanent population of only about 5,000 people, its average daily population is about 13,000, with peak weekends and holiday periods reaching 30,000 people per day. These wide fluctuations in service levels above the base population are typical of the recreational and resort communities in the area.

Although the Mojave River appears on maps as a major waterway in the region, it is an ephemeral stream for much of its length. Local communities extract groundwater, which is recharged by river flows, but do not directly divert significant amounts of surface water from the river. There is one dam on the Mojave River at the base of the San Bernardino Mountains—Mojave River Forks Dam, a 90 taf USACE flood control facility.

The 3.5 taf capacity Littlerock Reservoir provides water supply to Littlerock Creek Irrigation District and to Palmdale Water District. PWD funded most of a recent seismic rehabilitation of the 1924-vintage dam in exchange for control of the water supply for 50 years. Water from Littlerock Reservoir may be released into a ditch that conveys flows to PWD's Lake Palmdale, a 4.2 taf storage reservoir.

In the San Bernardino Mountains, Lake Arrowhead, owned by the Arrowhead Lake Association, is a 48 taf reservoir providing recreational opportunities and water supply for lakeshore residents.

Groundwater Supplies

Historically the South Lahontan Region has relied mostly on groundwater, which is the only water supply available in most parts of the region. Groundwater basin capacities in the Mojave River and Antelope Valley PSAs, for example, total about 70 maf each. (Economically usable storage is significantly less than this amount.) Water quality influences groundwater use. Some areas in the Mono-Owens area have highly mineralized groundwater due to geothermal activity, while saline groundwater is not uncommon in areas near playa lakes.

The Mojave River groundwater basin is a large alluvial formation in the Mojave Desert, the only local

Surface water is found in most desert waterways only after infrequent storms. If local groundwater resources are not sufficient to supply an area's needs, water must be imported to augment local supplies. This photo shows the Mojave River bed at Red Rock Canyon.

water source for residents in the western third of San Bernardino County (part of the basin is in the Colorado River Region). The Mojave River and groundwater basin act as one water source, with the river recharging the basin and groundwater discharging in several places to provide surface flows in the river. The basin is divided into subareas at hydrogeologic boundaries including the Helendale and Waterman Faults. The operational storage capacity of the basin is about 4.9 maf; currently there is about 3.0 maf of water in storage. The basin has experienced declining groundwater levels due to overextractions (see Mojave River adjudication section).

The Antelope Valley groundwater basin underlies the closed drainage in the westernmost part of the Mojave Desert in northern Los Angeles and southeastern Kern Counties. It provides most of the local water supplies to users in the high desert from the San Gabriel Mountains to the Sierras, including Edwards Air Force Base. Agricultural pumping from the basin has declined for several decades while urban extraction has increased due to rapid population growth.

Local Water Resources Management Issues

Owens Valley Area

In 1972, Inyo County filed suit against the City of Los Angeles, claiming that increased groundwater pumping for the second aqueduct was harming the Owens Valley environment. Inyo County asked that LADWP's groundwater pumping be analyzed in an

Searles Lake

The Mojave Desert has numerous playa lakes, dry or semi-dry lakebeds that occupy topographic low points in closed drainage basins. Playa lakes contain surface water only briefly after the region's infrequent rains. There may, however, be high groundwater levels immediately beneath an apparently dry lakebed. Groundwater found near these lakebeds is usually too mineralized for most beneficial uses, because salts have been concentrated in lakebed deposits during evaporation of the surface waters. Searles Lake in northwestern San Bernardino County is an example of an extremely mineralized playa lake.

Within geologic time, California's climate was much wetter than it is today. During the late Quaternary Period, the Owens River flowed into several (now dry) lakes in the Mojave Desert, filling Searles Lake to a depth of over 600 feet. Long-term deposition of evaporates in the lakebed created thick layers of salts and borate minerals. These deposits have been the basis of extensive mining operations at the lake, estimated to have produced more than $1 billion worth of mineral commodities.

Borax mining at the lakebed began as early as 1874. Current mining techniques entail pumping brines from lakebed sediments and processing them at onsite chemical plants to produce commodities such as sodium carbonate, sodium borate, and sodium sulfate. These chemicals are used in the manufacture of drugs, dyes, glass, glazes, paper, soap, detergent, enamel, chemical products, abrasives, gasoline additives, fire retardants, and metal alloys.

EIR. LADWP prepared an EIR in 1976 and another in 1979, both of which the Third District Court of Appeals found inadequate. In 1983, Inyo County and LADWP decided to work together to develop an EIR and water management plan to settle the litigation.

A third EIR was prepared jointly by LADWP and Inyo County and released in 1990. In 1991, both parties executed a long-term water management agreement delineating how groundwater pumping and surface water diversions would be managed to avoid significant decreases in vegetation, water-dependent recreational uses and wildlife habitat. Several entities challenged the adequacy of the EIR and in 1993 were granted *amici curiae* status by the Court of Appeals, allowing them to enter in the EIR review process. An agreement was subsequently executed in 1997, ending 25 years of litigation between Los Angeles and Inyo County.

LADWP and Inyo County have begun discussions on how to implement provisions of the agreements and EIR. Timelines for many provisions have already been developed and plans for major activities such as rewatering the Lower Owens River are under review.

Surface water diversions for Owens Valley agriculture from the Owens River began in the 1800s. The Los Angeles Aqueduct was completed in 1913. Owens Lake became a dry lakebed by 1929. On windy days, airborne particulates from the dry lakebed violate air quality standards in the southern Owens Valley. In 1997, the Great Basin Unified Air Pollution Control District ordered the City of Los Angeles to implement control measures at Owens Lake to mitigate the dust problems. Under the order, 8,400 acres of lakebed would be permanently flooded with a few inches of water, another 8,700 acres would be planted with grass and irrigated, and 5,300 acres would be covered with a four-inch layer of gravel. This order could reduce the city's diversions by 51 taf/yr or about 15 percent of its supply. In July 1998, a compromise was reached when LADWP agreed to begin work at Owens Lake by 2001 and to ensure that federal clean air standards would be met by 2006. In turn, the APCD agreed to scale back the improvements sought in its 1997 order. Under this agreement, LADWP's dust-control strategy may include shallow flooding, vegetation planting, and gravel placement. The implementation schedule requires that 6,400 acres of lakebed be treated by the end of 2001. By the end of 2006, an additional 8,000 acres would be treated, plus any additional lakebed necessary to bring particulate counts into compliance with federal air quality standards. The plan hinges on final approval from the Los Angeles City Council, the APCD's board, and the State Air Resources Board. The agreement also requires EPA to grant a 5-year extension of Clean Air Act requirements that direct states to abate particulate pollution by 2001 or seek an extension until 2006.

Mono Basin

Mono Lake, located east of Yosemite National Park at the base of the eastern Sierra Nevada, is the second largest lake completely within California. It is recognized as a valuable environmental resource. The lake is famous for its tufa towers and spires, structures formed by years of mineral deposition by its saline waters. The lake has no outlet. There are two islands in the lake that provide a protected breeding area for large colonies of California gulls and a haven for migrating waterfowl.

Much of the water flowing into Mono Lake comes from snowmelt runoff. Since 1941, LADWP has diverted water from Lee Vining, Walker, Parker, and Rush Creeks into tunnels and pipelines that carry the water to the Owens Valley drainage. There it is conveyed, together with Owens River flows, to Los Angeles via the LAA.

Diversions from its tributaries lowered Mono Lake's water level from elevation 6,417 feet in 1941 to a historic low of 6,372 feet in 1981. With decreased inflow of fresh water, the lake's salinity increased dramatically. When water levels drop to 6,375 feet or lower, a land bridge to Negit Island is created, allowing predators to reach gull rookeries; this first happened in 1978 and again during the 1987-92 drought.

As a result of these impacts, the lake and its tributaries have been the subject of extensive litigation between the City of Los Angeles and environmental groups since the late 1970s. In 1983, the California Supreme Court ruled that SWRCB has authority to reexamine past water allocation decisions and the responsibility to protect public trust resources where feasible. SWRCB issued a final decision on Mono Lake (Decision 1631) in 1994. The amendments to LADWP's water right licenses are set forth in the order accompanying the decision.

The order sets instream flow requirements for fish in each of the four streams from which LADWP diverts water. The order also establishes water diversion criteria to protect wildlife and other environmental resources in the Mono Basin. These water diversion

criteria prohibit export of water from Mono Basin until the lake level reaches 6,377 feet, and restrict Mono Basin water exports to allow the lake level to rise to an elevation of 6,391 feet in about 20 years. Once the water level of 6,391 feet is reached, it is expected that LADWP will be able to export about 31 taf/yr of water from the basin. The order requires LADWP to prepare restoration plans for the four streams from which it diverts and to restore part of the waterfowl habitat which was lost due to lake level decline. In May 1997, parties to the restoration planning process presented a signed settlement on Mono Basin restoration to the SWRCB. If approved, the settlement would guide restoration activities and annual monitoring through 2014. Parties to the settlement include LADWP, the Mono Lake Committee, DFG, State Lands Commission, DPR, California Trout, National Audubon Society, USFS, BLM, and The Trust for Public Land.

Key features of stream restoration plan include restoring peak flows to Rush, Lee Vining, Walker, and Parker Creeks; reopening abandoned channels in Rush Creek; and developing a monitoring plan. One of the restoration actions required by SWRCB—bypassing sediment around LADWP diversion dams—was deferred for further analysis. The waterfowl habitat restoration plan proposes that a Mono Basin waterfowl habitat restoration foundation administer a $3.6 million trust established by LADWP. Five of the parties to the agreement would serve as initial members of the foundation. Activities would include annual monitoring, restoring open water habitat adjacent to the lake, and rewatering Mill Creek. LADWP would continue its brine shrimp productivity studies, open several channels on Rush Creek, and make its Mill Creek water rights available for rewatering Mill Creek, based on the recommendations of the foundation.

The plans are being considered by SWRCB and a decision is expected at the end of 1998.

Mojave River Adjudication

The Mojave River groundwater basin has experienced overdraft since the early 1950s, with the largest increase in overdraft occurring in the 1980s. About 80 percent of basin recharge comes from the Mojave River. In 1990, the City of Barstow filed a complaint in Superior Court against the City of Adelanto seeking an average annual guaranteed flow of 30 taf to mitigate reduced runoff and declining groundwater levels in the Barstow area. The complaint also requested a writ of mandate against MWA to compel it to import water from the SWP. MWA filed a cross-complaint requesting a determination of water rights in the basin.

In 1991, the court ordered that the litigation be placed on hold to give parties time to negotiate a settlement and to develop a solution to the overdraft. A Mojave Basin adjudication committee was formed to facilitate data gathering and to draft a stipulated judgment and physical solution. The court's final ruling on basin adjudication was issued in January 1996. In its ruling, the court emphasized that the area has been in overdraft for decades and that MWA must alleviate overdraft through conservation and purchase of supplemental water. MWA was appointed as the basin watermaster.

The adjudication stipulated that any party pumping more than 10 af/yr became a party to the judgment and is bound by it. The judgment stated that each party has a right to its base annual production, which was its highest usage between 1986 and 1990. The judgment also required MWA to reduce this amount by at least 5 percent each year for four years as one way to achieve a physical solution to the longstanding overdraft. Any party exceeding its annual allotment must purchase replenishment water from MWA or from other parties to the judgment. If there is still overdraft after the end of the first five years of the stipulated judgment, water use in overdrafted subareas will be further reduced. The judgment recognized five basin subareas and required that if an upstream subarea does not meet its obligation to a downstream subarea, the upstream area must pay for supplemental water.

Supplemental water for the Mojave River Basin will come from MWA's SWP entitlement, or from water marketing arrangements, and will be delivered through the California Aqueduct. In March 1997, MWA began constructing its Mojave River pipeline, extending about 71 miles from the California Aqueduct to Newberry Springs, a rural community east of Barstow. MWA also recently purchased the permanent right to 25 taf of additional SWP annual entitlement, nearly a 50 percent increase from the agency's previous entitlement. The combination of reduced pumping, increased SWP deliveries and other imports, and new delivery facilities are expected to reduce overdraft in the basin.

Antelope Valley Water Management

The Antelope Valley Water Group was formed in 1991 to provide coordination among valley water agen-

cies and other interested entities. AVWG members include the Cities of Palmdale and Lancaster, Edwards AFB, AVEK, Antelope Valley United Water Purveyors Association, Los Angeles County Waterworks Districts, PWD, Rosamond Community Services District, and Los Angeles County. AVWG completed an Antelope Valley water resources study in 1995 to address regional water management issues.

The study evaluated the valley's existing and future water supplies from groundwater, the SWP, Littlerock Reservoir, and recycling, and compared these supplies with projected water demands. The study concluded that water supply reliability is low in the study area—full 1998 demands would be met only half the time without overdrafting groundwater resources. The study recommended water conservation, recycling, and conjunctive use measures to reduce expected shortages. The study identified three sites (two on Amargosa Creek and one on Littlerock Creek) with high potential for groundwater recharge through spreading and identified SWP water, recycled water, and local runoff as potential recharge sources. The study also identified several potential groundwater injection sites within existing Los Angeles County Waterworks and PWD municipal wellfields. Treated SWP water was identified as a potential recharge source.

In 1996, PWD adopted a water facilities master plan for its service area, updating a 1988 plan. PWD relies on three water sources: Littlerock Reservoir, local groundwater, and SWP water. The plan indicates that about 40 percent of PWD supply is from groundwater. Declining groundwater levels have been a local concern in the Palmdale area, although extractions presently appear to be within the basin's perennial yield. The plan also indicates that existing supplies are insufficient to meet drought demands. Average year shortages are projected to occur by 2005.

To meet drought year demands, the plan calls for the construction of up to 12 new production wells. The plan's draft EIR identified declining groundwater levels as an unavoidable impact of constructing new wells. Mitigation measures recommended included conservation and drought year demand reduction, conjunctive use programs (as identified in the Antelope Valley water resources study), acquisition of an additional 3.1 taf/yr of SWP entitlement, participation in water transfers, and development of recycled water.

Interstate Groundwater Basins

California and Nevada share three interstate groundwater basins in the South Lahontan Region: Fish Lake Valley, crossed by Highway 168 east of Westgard Pass; Pahrump Valley, located to the east of Death Valley; and Mesquite Valley, just south of Pahrump Valley. Groundwater extraction on the California side of the border supports small-scale agricultural development, largely for alfalfa. Pahrump Valley is the most populated of the three valleys; most of its development is located in Nevada around the community of Pahrump. Pahrump and Mesquite Valleys are within about 35 miles of the rapidly growing Las Vegas metropolitan area. In the early 1990s, the Southern Nevada Water Authority proposed exporting groundwater from several rural counties in central Nevada to help meet Las Vegas' rapidly increasing need for water. Opposition by rural Nevada counties to SNWA's proposal caused SNWA to defer this project. Inyo County residents have historically been concerned about the proximity of Las Vegas to the interstate basins, although no new interstate issues have come up since SNWA's proposed project.

Water Management Options for the South Lahontan Region

Table 9-11 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 9A-2 in Appendix 9A) based on a set of fixed criteria discussed in Chapter 6.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. Reducing outdoor water use to 0.8 ET_o in new development would attain 20 taf/yr of depletion reductions, while extending this measure to include existing development would reduce depletions by 31 taf/yr. Reducing residential indoor water use to 60 and 55 gpcd would attain depletion reductions of 7 and 15 taf/yr, respectively. Reducing CII water use by an additional 3 and 5 percent would attain 2 and 4 taf/yr of depletion reductions, respectively. Reducing distribution system losses to 7 and 5 percent would save 4 and 12 taf/yr, respectively.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs

TABLE 9-11

South Lahontan Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to $0.8ET_o$	Retain	
Indoor Water Use	Retain	
Interior CII Water Use	Retain	
Distribution System Losses	Retain	
Agricultural		
Seasonal Application Efficiency Improvements	Retain	
Flexible Water Delivery	Defer	No significant depletion reductions attainable.
Canal Lining and Piping	Defer	No significant depletion reductions attainable.
Tailwater Recovery	Defer	No significant depletion reductions attainable.
Modify Existing Reservoirs/Operations		
Remove Sediment from Littlerock Reservoir	Defer	Excessive costs for additional yield.
New Reservoirs/Conveyance Facilities		
—	—	—
Groundwater/Conjunctive Use		
—	—	—
Water Marketing		
Mojave Water Agency	Retain	
Palmdale Water District	Retain	
Water Recycling		
Water recycling options	Defer	Water recycling options in this region do not generate new water supply.
Desalting		
Brackish Groundwater		
—	—	—
Seawater		
—	—	—
Other Local Options		
Line Palmdale Ditch	Defer	No net increase in supply.
Reduce Outflow to Playa Lakes	Defer	Restrictions on use of flows that provide recharge to overdraft basins. Costs are high and water quality is poor.
Statewide Options		
—	—	See Chapter 6.

are considered as options. It is estimated that water savings of 2, 3, and 5 taf/yr could be achieved in this region, by improving SAE to 76, 78, and 80 percent, respectively. Options for flexible water delivery and canal lining and piping are not feasible in this region because most water supply comes from individual wells with minimal conveyance facilities.

Modify Existing Reservoirs or Operations

Sediment has accumulated in Littlerock Reservoir and minor additional yield could be realized by removing the sediment. Studies are now under way to evaluate the costs and benefits of this option. Preliminary estimates indicate that the cost of this option is in the order of $2,000/af. Because of the high costs, this option was deferred.

New Reservoirs or Conveyance Facilities

There are no proposed new reservoir developments in this region. The region's aridity and consequent lack of surface water resources make new reservoirs infeasible. Future local water resources development will be based on groundwater sources.

Water Marketing

The California Aqueduct could convey purchased water to MWA's distribution system to supply some of the region's rapidly urbanizing areas. MWA has entered into a multi-year banking and exchange agreement with Solano County Water Agency. During wet years, SCWA can bank up to 10 taf of its annual SWP entitlement in MWA's groundwater basin. During drought years, SCWA can take part of MWA's SWP entitlement in exchange (up to half the banked amount with a maximum of 10 taf/yr). MWA is also pursuing two demonstration water marketing projects of 2 taf each. PWD is seeking to purchase 3.1 taf/yr of SWP entitlement from Central Valley agricultural water purveyors. Other voluntary marketing arrangements could be developed through option agreements, storage programs, and purchases of water through the DWB or other spot markets.

Capacity has been developed to store additional imported supplies in the Mojave River Basin at MWA's Rock Springs groundwater recharge facility near Hesperia. Additional recharge facilities in the Barstow area are in the final planning stages, which would further increase MWA's ability to take delivery of imported supplies when its Mojave River Aqueduct is completed. Sufficient basin storage is available to store water in wet years when more SWP supplies or purchased supplies might be available.

Water Recycling

Water recycling options are deferred for this region because planned projects would not generate new supply.

Other Local Options

The ditch that conveys water from Littlerock Reservoir to Palmdale Lake has an estimated 20 percent conveyance loss, which could be reduced by canal lining. Canal lining would reduce groundwater recharge by approximately 1 taf/yr, resulting in no net increase in water supply. This option was deferred.

Some flow of the Mojave River reaches Soda Lake where the flow is lost to evaporation. Annual outflow past Afton Canyon averages 8.4 taf. However, the basin adjudication restricts use of flows that provide recharge to downstream subareas of the basin that are in overdraft. Reducing outflow to Soda Lake was deferred as an option.

Likewise, local storm runoff collects in many small playas throughout the basin. These playas generally do not contribute to groundwater recharge, due to the low permeability of playa soils. Water collected in the playas evaporates, rather than recharging groundwater. Diversion or collection of runoff to playas and recharging it to groundwater basins could increase groundwater supplies by eliminating the evaporation. Six dry lakebeds could potentially store an additional 1.8 taf once every five years. Costs for this option are $1,000 to $3,300/af. Water quality at the playas is generally poor, with high levels of salts and minerals. This option was deferred.

Statewide Options

Statewide water supply augmentation options are discussed and quantified in Chapter 6.

Options Likely to be Implemented in the South Lahontan Region

Water supplies are not available to meet all of the region's 2020 water demands in average or drought years. Applied water shortages are forecasted to be 270 taf in average years and 308 taf in drought years. Most of the region's shortage will be in the Mojave River planning subarea. Water shortages in the Antelope Valley subarea are forecast only in drought years. Ranking of retained water management options for the South Lahontan Region is summarized in Table 9-12. Table 9-13 summarizes options that can likely be implemented by 2020 to relieve the shortages. The options likely to be implemented in this region include SWP supplies and water transfers conveyed by the California Aqueduct.

TABLE 9-12

Options Ranking for South Lahontan Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Urban				
Outdoor Water Use to 0.8 ET_o-New Development	M	750	20	20
Outdoor Water Use to 0.8 ET_o-New and Existing Development	M	[b]	31	31
Indoor Water Use (60 gpcd)	M	400	7	7
Indoor Water Use (55 gpcd)	M	600	15	15
Interior CII Water Use (3%)	M	500	2	2
Interior CII Water Use (5%)	M	750	4	4
Distribution System Losses (7%)	M	200	4	4
Distribution System Losses (5%)	M	300	12	12
Agricultural				
Seasonal Application Efficiency Improvements (76%)	H	100	2	2
Seasonal Application Efficiency Improvements (78%)	M	250	3	3
Seasonal Application Efficiency Improvements (80%)	M	450	5	5
Water Marketing				
Mojave Water Agency	H	[b]	4	4
Palmdale Water District (3.1 taf SWP entitlement)	H	[b]	3	2
Statewide Options				
See Chapter 6.				

[a] All or parts of the amounts shown for highlighted options have been included in Table 9-13.
[b] Data not available to quantify.

TABLE 9-13

Options Most Likely to be Implemented by 2020 (taf)
South Lahontan Region

	Average	*Drought*
Applied Water Shortage	**270**	**308**
Options Likely to be Implemented by 2020		
Conservation	56	56
Modify Existing Reservoirs/Operations	-	-
New Reservoirs/Conveyance Facilities	-	-
Groundwater/Conjunctive Use	-	-
Water Marketing	7	6
Recycling	-	-
Desalting	-	-
Other Local Options	-	-
Statewide Options	174	204
Expected Reapplication	33	42
Total Potential Gain	**270**	**308**
Remaining Applied Water Shortage	**0**	**0**

FIGURE 9-4

Colorado River Hydrologic Region

Colorado River Hydrologic Region

. . .

Description of the Area

The Colorado River Region encompasses the southeastern corner of California. The region's northern boundary, a drainage divide, begins along the southern edge of the Mojave River watershed in the Victor Valley area of San Bernardino County and extends northeast across the Mojave Desert to the Nevada stateline. The southern boundary is the Mexican border. A drainage divide forms the jagged western boundary through the San Bernardino, San Jacinto, and Santa Rosa Mountains, and the Peninsular Ranges (including the Laguna Mountains). The Nevada stateline and the Colorado River (the boundary with Arizona) delineate the region's eastern boundary (Figure 9-4).

Covering over 12 percent of the total land area in the State, the region is California's most arid. It includes volcanic mountain ranges and hills; distinctive sand dunes; broad areas of Joshua tree, alkali scrub, and cholla communities; and elevated river terraces. Much of the region's topography consists of flat plains punctuated by hills and mountain ranges. The San Andreas fault traverses portions of the Coachella and Imperial Valleys. A prominent topographic feature is the Salton Trough in the south-central part of the region.

The climate for most of the region is subtropical desert. Average annual precipitation is much higher in the western mountains than in the desert areas. Winter snows generally fall above 5,000 feet; snow depths can reach several feet at the highest levels during winter. Most of the precipitation in the region falls during the winter; however, summer thunderstorms can produce rain and local flooding. Despite its dry climate and rugged terrain, the region contains large and productive agricultural areas and popular vacation resorts. Table 9-14 shows the region's population and crop acreage for 1995 and 2020.

TABLE 9-14
Population and Crop Acreage

	Population (thousands)	*Irrigated Crop Acreage (thousands of acres)*
1995	533	749
2020	1,096	750

Coachella Valley date palms. The Colorado River Region is the main location in California where dates are grown for commercial production.

Most of the population is concentrated in the Coachella and Imperial Valleys. Major cities in the Coachella Valley include Palm Springs, Indio, and Palm Desert. Other urban centers in the region are the Cities of El Centro, Brawley, and Calexico in Imperial Valley; the Cities of Beaumont and Banning in the San Gorgonio Pass area; and the Cities of Needles and Blythe along the Colorado River.

Agriculture is an important source of income for the region. Almost 90 percent of the developed private land is used for agriculture, most of which is in the Imperial, Coachella, and Palo Verde Valleys. The primary crops are alfalfa, winter vegetables, spring melons, table grapes, dates, Sudan grass, and wheat. Recreation and tourism are another important source of income for the region. In Coachella Valley, the Palm Springs area and adjoining communities are an important resort and winter golf destination. Recreational opportunities provided by the more than 100 golf courses in the Coachella Valley, water-based recreation on the Colorado River and Salton Sea, and desert camping all contribute to the area's economy.

Water Demands and Supplies

Table 9-15 shows the water budget for the Colorado River Region. Agricultural water demand makes up the majority of the water use in the region. There are two major areas where water is used for wildlife habitat in the region, the Salton Sea National Wildlife Refuge and the Imperial Wildlife Area. There are also several private wetlands.

About 90 percent of the region's water supply is from surface deliveries from the Colorado River (through the All American and Coachella Canals, local diversions, and the Colorado River Aqueduct by means of an exchange for SWP water). Other supplies are from groundwater, SWP water, local surface water, and recycled water. Bulletin 160-98 base year groundwater overdraft in the region was estimated to be about 70 taf and occurs in the Coachella Valley.

Major water agencies in the region are the Palo Verde Irrigation District, Imperial Irrigation District, Coachella Valley Water District, Bard Water District, Mojave Water Agency, Desert Water Agency, and San Gorgonio Pass Water Agency.

The region's primary shortages with existing supplies are expected to occur in the Coachella planning subarea because of groundwater overdraft. (In the future, reduction in California's Colorado River water use to the State's basic apportionment creates an average year shortage of as much as 0.9 maf in the South Coast Region. This 2020 shortage is shown in the South Coast water budget.)

Supplies from the Colorado River

Most of the water supply in the region comes from the Colorado River, an interstate (and international) river whose use is apportioned among the seven Colorado River Basin states by a complex body of statutes, decrees, and court decisions known collectively as the law of the river. Table 9-16 summarizes key elements of the law of the river. USBR acts as the watermaster for the Colorado River, and all users of Colorado River water must contract with USBR for their supplies. Figure 9-4 shows the locations of key Colorado River storage and conveyance facilities.

TABLE 9-15

Colorado River Region Water Budget (taf)[a]

	1995		*2020*	
	Average	***Drought***	***Average***	***Drought***
Water Use				
Urban	418	418	740	740
Agricultural	4,118	4,118	3,583	3,583
Environmental	39	38	44	43
Total	**4,575**	**4,574**	**4,367**	**4,366**
Supplies				
Surface Water	4,154	4,128	3,920	3,909
Groundwater	337	337	285	284
Recycled and Desalted	15	15	15	15
Total	**4,506**	**4,479**	**4,221**	**4,208**
Shortage	**69**	**95**	**147**	**158**

[a] Water use/supply totals and shortages may not sum due to rounding.

Hoover Dam and Lake Mead. Lake Mead and Lake Powell are the largest of the Colorado River system reservoirs.

Courtesy of USBR

TABLE 9-16

Key Elements of the Law of the River

Document	*Date*	*Main Purpose*
Colorado River Compact	1922	Equitable apportionment of the water from the Colorado River system between the two basins. The Upper Basin and the Lower Basin are each provided a basic apportionment of 7.5 maf annually of consumptive use. The Lower Basin is given the right to increase its consumptive use an additional 1 maf annually.
Boulder Canyon Project Act	1928	Authorized USBR to construct Boulder (Hoover) Dam and the All American Canal (including the Coachella Canal), and gave congressional consent to the Colorado River Compact. Also provided that all users of Colorado River water must enter into a contract with USBR for use of the water.
California Limitation Act	1929	Limited California's share of the 7.5 maf annually apportioned to the Lower Basin to 4.4 maf annually, plus no more than half of any surplus waters.
Seven Party Agreement	1931	An agreement among PVID, IID, CVWD, MWDSC, City of Los Angeles, City of San Diego, and County of San Diego to recommend to the Secretary of Interior how to divide use of California's apportionment among the California water users. Details are shown in Table 9-17.
U.S. - Mexican Treaty	1944	Guarantees Mexico a supply of 1.5 maf annually of Colorado River water.
U.S. Supreme Court Decree in A*rizona v. California, et al.*	1964	Apportions water from the mainstream of the Colorado River among the Lower Division states. When the Secretary determines that 7.5 maf of mainstream water is available, it is apportioned 2.8 maf to Arizona, 4.4 maf to California, and 0.3 maf to Nevada. Also quantifies tribal water rights for specified tribes, including 131,400 af for diversion in California.
Colorado River Basin Project Act	1968	Requires Secretary of the Interior to prepare long-range operating criteria for major Colorado River reservoirs.
U.S. Supreme Court Decree in *Arizona v. California, et al.*	1979	Quantifies Colorado River mainstream present perfected rights in the Lower Basin states.

TABLE 9-17

Annual Apportionment of Use of Colorado River Water

(all amounts represent consumptive use)

Interstate/International	
Upper Basin States (Wyoming, Utah, Colorado, New Mexico, small portion of Arizona)	7.5 maf
Lower Basin States (Arizona, Nevada, California)	7.5 maf
Arizona	2.8 maf
Nevada	0.3 maf
California	4.4 maf
Republic of Mexico[a]	1.5 maf

[a] Plus 200 taf of surplus water, when available. Water delivered to Mexico must meet specified salinity requirements.

Intrastate (Seven Party Agreement)[b]	
Priority 1	Palo Verde Irrigation District (based on area of 104,500 acres).
Priority 2	Lands in California within USBR's Yuma Project (not to exceed 25,000 acres).
Priority 3	Imperial Irrigation District and lands served from the All American Canal in Imperial and Coachella Valleys, and Palo Verde Irrigation District for use on 16,000 acres in the Lower Palo Verde Mesa.
Priorities 1 through 3 collectively are not to exceed 3.85 maf/yr. There is no specified division of that amount among the three priorities.	
Priority 4	MWDSC for coastal plain of Southern California-550,000 af/yr.
Priority 5	An additional 550,000 af/yr to MWDSC, and 112,000 af/yr for the City and County of San Diego[c].
Priority 6	Imperial Irrigation District and lands served from the All American Canal in Imperial and Coachella Valleys, and Palo Verde Irrigation District for use on 16,000 acres in the Lower Palo Verde Mesa, for a total not to exceed 300,000 af/yr.
Total of Priorities 1 through 6 is 5.362 maf/yr.	
Priority 7	All remaining water available for use in California, for agricultural use in California's Colorado River Basin.

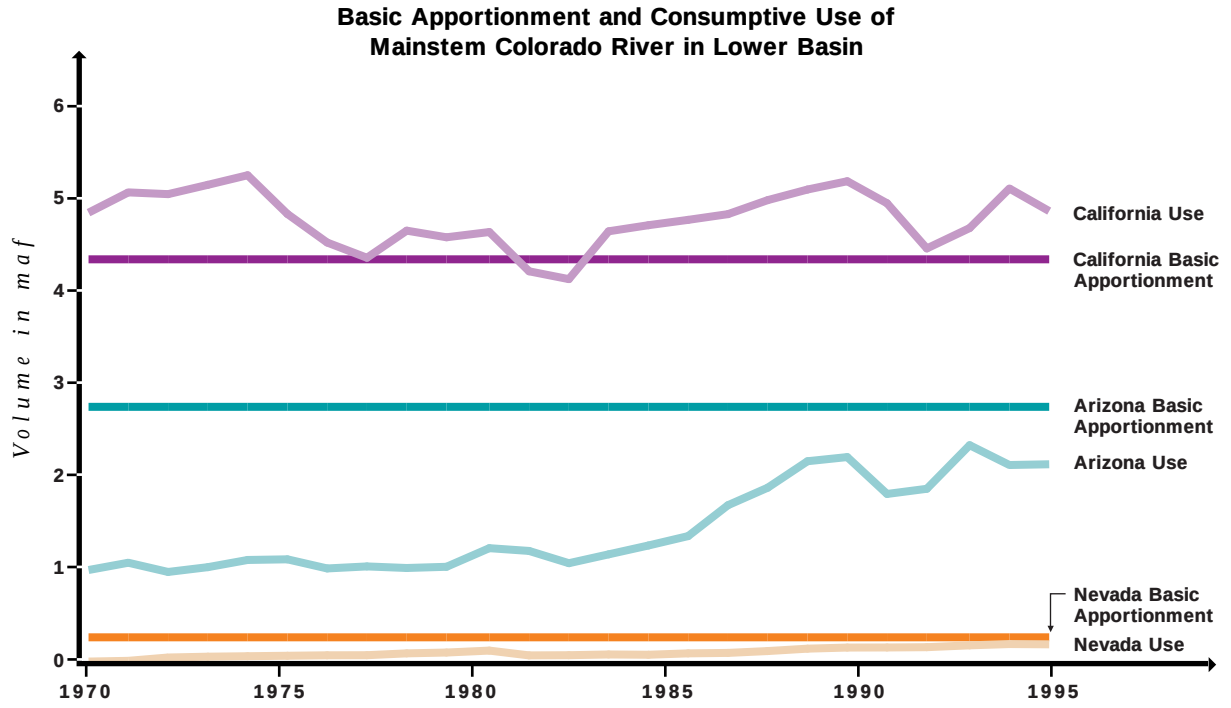
[b] Indian tribes and miscellaneous present perfected right holders that are not identified in California's Seven Party Agreement have the right to divert up to approximately 85 taf /yr (equating to about 50 taf/yr of consumptive use) within California's 4.4 maf basic apportionment. These users are presently consumptively using approximately 32 taf/yr (assuming about 25 taf/yr of unmeasured return flow).

[c] Subsequent to execution of the Seven Party Agreement, San Diego executed a separate agreement transferring its apportionment to MWDSC.

Within California, local agencies' apportionments of Colorado River water were established under the Seven Party Agreement (Table 9-17), which has been incorporated into water delivery contracts which the Secretary of the Interior has executed with California water users. Uses occurring within a state are charged to that state's allocation. Thus, federal water uses or uses associated with federal reserved rights (e.g., tribal water rights) must also be accommodated within California's basic apportionment of 4.4 maf/yr plus one-half of any available surplus water.

The major local agencies in California using Colorado River water in the Colorado River Region are PVID, BWD, IID, and CVWD. The Reservation Division of USBR's Yuma Project provides water to Colorado River Indian tribes in California. The remainder of California's Colorado River water use occurs in the South Coast Region (Chapter 7). Figure 9-5 is a plot of Lower Basin states' apportionments compared with historical Colorado River water use. As shown in the figure, California's use has historically exceeded its basic apportionment, because California has been allowed to divert Arizona's and Nevada's unused apportionments, and to divert surplus water. With completion of the Central Arizona Project and the 1996 enactment of a state groundwater banking act,

FIGURE 9-5



Arizona used more than its basic apportionment in 1997. Reduction of California's Colorado River use from current levels to 4.4 maf annually (when surplus water is not available) has significant water management implications for the South Coast Region. In calendar year 1996, actual consumptive use of the Lower Basin states (without considering USBR's unmeasured return flow credit of 239 taf) was:

Nevada	241 taf
Arizona	2,813 taf
California	5,256 taf
Total Lower Basin	8,310 taf

Within the Colorado River Region, IID, BWD, and PVID receive virtually all of their supplies from the Colorado River. IID and CVWD's Colorado River supplies are diverted into USBR's All American Canal at Imperial Dam; CVWD is served from the Coachella Branch of the AAC. PVID diverts via the Palo Verde Canal from the Colorado River near Blythe. BWD receives its supplies from facilities of USBR's Yuma Project, which serves lands in both California and Arizona.

The interstate allocations provided in the 1922 Compact were made after a period of relatively wet hydrology on the Colorado River. Some have suggested that the allocations overstate the river's normally available water supply, even without consideration of subsequent calls on that water supply for tribal water rights and endangered species fishery water needs. Table 9-18 provides an overview of average river hydrology. While consumptive use from the mainstem in the Lower Basin is assumed to be its basic apportionment of 7.5 maf, Upper Basin use is still well below its Colorado River Compact apportionment. Current

TABLE 9-18

Estimated Colorado River Flow and Uses[a]

	maf
Average Flow (1906-95)	
Upper Basin	15.1
Lower Basin	1.4
Total	**16.5**
Current Uses	
Upper Basin	3.8
Lower Basin (mainstem)[b]	7.5
Mexico	1.5
Mainstem Evaporation and Losses	1.9
Total	**14.7**
Average Flow into Reservoir Storage (16.5 - 14.7)	**1.8**

[a] Prepared by the CRB.

[b] Reflects restriction on MWDSC's diversion as Central Arizona Project and Southern Nevada Water System increase diversions to Arizona's and Nevada's basic apportionments.

USBR's Imperial Dam on the Colorado River. The structures in the foreground are a series of desilting basins used to reduce the sediment load of river water before it enters the All American Canal.

Courtesy of USBR

projections are that the Upper Basin will not reach its full Compact apportionment until after 2060.

Supplies from Other Sources

Local agencies contracting with the SWP for part of their supplies are shown in Table 9-19.

Neither CVWD nor DWA have facilities to take direct delivery of SWP water. Instead, both agencies have entered into exchange agreements with MWDSC, whereby MWDSC releases water from its Colorado River Aqueduct into the Whitewater River for storage in the upper Coachella Valley groundwater basin. In turn, MWDSC takes delivery of an equal amount of the agencies' SWP water. San Gorgonio Pass Water Agency, which serves the Banning/Beaumont area, also lacks the facilities to take delivery of SWP water, and to date has received no actual supply from the SWP. SGPWA will receive SWP supply when the Department completes its extension of the East Branch of the California Aqueduct in 2000.

Groundwater, local surface water, and water recycling provide the remaining supplies for this region. CVWD, working with DWA, has an active groundwater recharge program for the upper end of the Coachella Valley (generally, the urbanized part of the valley). CVWD recharges groundwater with imported Colorado River supplies and with Whitewater River flows using percolation ponds constructed in the Windy Point area. CVWD and DWA levy extraction fees on larger groundwater users in the upper Coachella

TABLE 9-19

SWP Contractors in the Colorado River Region

Agency	*Maximum Annual Contract Entitlement (taf)*	*SWP Deliveries in 1995 (taf)*
Coachella Valley WD	23.1	23.1
Desert Water Agency	38.1	38.1
Mojave Water Agency[a]	75.8	8.7
San Gorgonio Pass Water Agency	17.3	0

[a] Contract entitlement covers both South Lahontan and Colorado River Regions; 7.3 taf of this amount is allocated to Colorado River Region.

Valley. Imperial Valley, the largest water-using area in the region, does not have significant supplies of usable groundwater.

Local Water Resources Management Issues

Management of California's Colorado River Water

The major water management issue in this region is California's use of Colorado River water in excess of its basic annual apportionment of 4.4 maf. In the past, Arizona and Nevada were not using the full amount of their basic apportionments, and in accordance with the law of the river, California was able to use the amount apportioned to, but not used by, Nevada and Arizona. Discussions among the seven basin states and ten Colorado River Indian Tribes over changes to Colorado River operating criteria and ways for California to reduce its Colorado River water use began as early as 1991. The drought in Northern California prompted California to request that USBR make surplus water available, so that maximum use could be made of Colorado River water in Southern California. These discussions over changes to reservoir operations and how surplus or shortage conditions could be established continued for a time in a forum known as the "7/10 process."

More recently, the California local agencies, working through the Colorado River Board of California, have been developing a proposal for discussion with the other basin states to illustrate how, over time, California would reduce its use to the basic apportionment of 4.4 maf/yr. Drafts of the proposal, known as the Colorado River Board draft 4.4 Plan, have been shared with the other states. Efforts are being made to reach intrastate consensus on the plan in 1998. As Bulletin 160-98 goes to press, the most current version of the draft plan is the December 1997 version. The following text is based on that version.

As currently formulated, the draft plan would be implemented in two phases. The first phase (between the present and 2010 or 2015) would entail implementing already identified measures (such as water conservation and transfers) to reduce California's Colorado River water use to about 4.6 to 4.7 maf/yr. The second phase would implement additional measures to reduce California's use to its basic annual 4.4 maf apportionment in those years when neither surplus water nor other states' unused apportionments was available. One of the fundamental assumptions made in the plan is that MWDSC's Colorado River Aqueduct will be kept full, by making water transfers from agricultural users in the Colorado River Region to urban water users in the South Coast Region. (The Colorado River Aqueduct's capacity is a maximum of

Imperial Irrigation District, formed in 1911, acquired conveyance facilities constructed by a bankrupt privately owned irrigation company. In 1918, IID constructed Rockwood Heading (shown here) on the original canal system. Keeping the canal system from being choked by the Colorado River's high sediment loading was difficult; note the dredge shown in the background. These early facilities were subsequently replaced by the All American Canal.

Courtesy of Imperial Irrigation District.

1.3 maf/yr. However, as shown in Table 9-17, MWDSC has a fourth priority right to only 550 taf annually—the remaining capacity of the aqueduct has historically been filled with unused apportionment water of other entities or with water from hydrologic surpluses.)

In the December 1997 draft plan, specific actions were included in the first phase: core water transfers (every year water transfers) such as the existing IID/MWDSC agreement and the proposed IID/SDCWA transfer; seepage recovery from unlined sections of the All American and Coachella Canals; drought year water transfers similar to the PVID/MWDSC pilot project; groundwater banking in Arizona; and conjunctive use of groundwater in areas such as the Coachella Valley. The actions are described in more detail below. The draft plan recognizes that transfers of conserved water must be evaluated in the context of preserving the Salton Sea's environmental resources, and also that plan elements must address environmental impacts on the lower Colorado River and its listed species.

Other actions to occur as part of the first phase would include implementation of the San Luis Rey Indian water rights settlement authorized in PL 100-675 and implementation of measures to administer agricultural water entitlements within the first three priorities of the Seven Party Agreement. Examples of such measures include quantifying amounts of water conserved or transferred, and annually reconciling water use with water allocations (e.g., overrun accounting).

An important element of the CRB draft 4.4 plan is the concept that existing reservoir operating criteria be changed by USBR to make optimum use of the river's runoff and available basin storage capacity. California agencies developed new proposed operating criteria that are included in the draft plan. The draft plan contemplates that changes in operating criteria would be part of both the first and second phases. The other basin states have been cautious in their reaction to California's proposals for reservoir reoperation, and have suggested, for example, that new criteria should not be implemented until California has prepared the environmental documents and executed the agreements that would be needed to begin implementation of the plan. (In its 1995 five-year review of Colorado River operating criteria, USBR had announced that it planned no changes to existing criteria.)

The second phase of the CRB draft 4.4 plan would include additional average year and drought year water transfers. Specifics on these transfers would be developed during the first phase of plan implementation. One suggested component is construction of desalting facilities on rivers tributary to the sea, to divert and treat agricultural drainage water that would otherwise enter the sea. The treated water could be conveyed to urban water users in the South Coast Region via the Colorado River Aqueduct. As with any alternative that would reduce the amount of relatively fresh water reaching the sea, the environmental impacts of this approach would require careful evaluation. Other components of the second phase would include further transfers of conserved agricultural water to the

New Parker Dam photo

USBR's Parker Dam on the Colorado River impounds Lake Havasu. At this location, the Colorado River forms the stateline between California and Arizona. MWDSC's Colorado River Aqueduct and the Central Arizona Project divert from Lake Havasu.

South Coast and further work on reservoir operating criteria. Implementation of some elements of phase two of the plan may extend beyond the Bulletin 160-98 planning horizon.

Tribal Water Rights

Colorado River Indian Tribes. As a result of the 1964 U.S. Supreme Court decree in Arizona v. California, California's basic apportionment of Colorado River water was quantified and five lower Colorado River Indian Tribes were awarded 905 taf of annual diversions, 131 taf of which were allocated for diversion in and chargeable to California pursuant to a later supplemental decree.

In 1978, the tribes asked the court to grant them additional water rights, alleging that the U.S. failed to claim a sufficient amount of irrigable acreage, called omitted lands, in the earlier litigation. The tribes also raised claims called boundary land claims for more water based on allegedly larger reservation boundaries than had been assumed by the court in its initial award. In 1982, the special master appointed by the Supreme Court to hear these claims recommended that additional water rights be granted to the Indian tribes. In 1983, however, the Supreme Court rejected the claims for omitted lands from further consideration and ruled that the claims for boundary lands could not be resolved until disputed boundaries were finally determined. Three of the five tribes—Fort Mojave Indian Tribe, Quechan Indian Tribe, and Colorado River Indian Tribe—are pursuing additional water rights related to the boundary lands claims. A settlement has been reached on the Fort Mojave claim and may soon be reached on the CRIT claim. Both settlements would then be presented to the special master. The Quechan claim has been rejected by the special master on the grounds that any such claim was necessarily disposed of as part of a Court of Claims settlement entered into by the tribe in a related matter in the mid-1980s. As with all claims to water from the mainstem of the Colorado River and any determination by the special master, only the U.S. Supreme Court itself can make the final ruling.

If both the Fort Mojave and CRIT settlements were approved, the tribes would receive water rights in addition to the amounts granted them in the 1964 decree.

San Luis Rey Indian Water Rights Settlement Act. The San Luis Rey Indian Water Rights Settlement Act (Public Law No. 100-675; 102 Stat. 4000 [1988]) is to provide for the settlement of the reserved water rights claims of the La Jolla, Rincon, San Pasqual, Pauma, and Pala Bands of Mission Indians. Litigation (affecting the interests of the United States, the City of Escondido, the Escondido Mutual Water Company, the Vista Irrigation District, and the Bands) and proceedings before the Federal Energy Regulatory Commission involved tribal water rights claims to the waters of the San Luis Rey River and questions about the validity of rights-of-way granted by the U.S. across tribal and allotted lands. The act authorizes and directs the Secretary of the Interior to arrange for a 16 taf/yr supplemental supply of water to benefit the Bands and the local communities. This supply can be obtained either from water development from public lands in California outside the service area of the CVP, from water salvaged as the result of lining part of the AAC or Coachella Canal, or through a contract with MWDSC. Title II of PL 100-675 authorized the Secretary of the Interior to line parts of the canals, and permitted the Secretary to enter into an agreement or agreements with PVID, IID, CVWD, and/or MWDSC for the construction or funding. The act did not authorize appropriation of federal funds for canal lining.

Colorado River Board of California

The Colorado River Board of California is the State agency responsible for administering California's Colorado River water allocation, and for dealing with the other basin states on river management issues. The Board is composed of six members representing the California agencies who were signatories to the 1931 Seven-Party Agreement, two public members, and two ex-officio members (the directors of the Department and DFG). The six local agencies represented on the CRB are CVWD, IID, LADWP, MWDSC, PVID, and SDCWA. CRB's office and staff are located in Glendale.

Water Conservation Programs

There have been several large-scale water conservation actions involving Colorado River water users, as shown in Table 9-20.

Salton Sea

The present day Salton Sea was formed in 1905, when Colorado River water flowed through a break in a canal that had been constructed along the U.S./Mexican border to divert the river's flow to agricultural lands

TABLE 9-20

Existing Colorado River Region Water Conservation Actions

Year	*Action*	*Participants*	*Comments/Status*	*Estimated Savings*
1980	Line 49 miles of Coachella Branch of All American Canal	USBR, CVWD, MWDSC	Project completed.	132 taf/yr
1988	IID distribution system improvements and on-farm water management actions	IID, MWDSC	Multi-year agreement, extends into 2033. Projects MWDSC has funded include canal lining, regulatory reservoir and spill interceptor canal construction, tailwater return systems, non-leak gates, 12-hour delivery of water, drip irrigation systems, linear-move irrigation systems, and system automation. MWDSC has funded over $150 million for conservation program costs through 1997.	107 taf/yr in 1998
1992	Groundwater banking in Arizona	MWDSC, CAWCD, SNWA	Test program to bank up to 300 taf.	MWDSC and SNWA have stored 139 taf in Arizona groundwater basins.
1992	PVID land fallowing	PVID, MWDSC	Project completed. Two-year land fallowing test program. Covered 20,215 acres in PVID. MWDSC paid $25 million to farmers over a two-year period.	Total of 186 taf was made available from the program, although the water was subsequently released from Lake Mead when flood control releases were made from the reservoir.
1995	Partnership agreement	USBR, CVWD	Provides, among other things, for studies to optimize reasonable beneficial use of water in the district.	N/A

in the Imperial Valley. Until that break was repaired in 1907, the full flow of the river was diverted into the Salton Sink, a structural trough whose lowest point is about 278 feet below sea level. Within geologic time, the Colorado River's course has altered several times. At times, the river discharged to the Gulf of California as it does today. At other times it flowed into the Salton Sink. Lake Cahuilla, the most recent of several prehistoric lakes to have occupied the Salton Sink, dried up some 300 years ago.

Over the long term, the sea's elevation has gradually increased, going from a low on the order of -250 feet in the 1920s to its present level of about -226 feet. The sea's maximum elevation in recent years was -225.6 in 1995. Since some shoreline areas are relatively flat, a small change in elevation can result in a large difference in the extent of shoreline submerged. Levees have been constructed to protect adjacent farmland and structures at some sites along the shoreline; the remaining managed acreage of the Salton Sea National Wildlife Refuge is also protected from the sea by levees.

The Salton Sea is the largest lake located entirely within California, with a volume of about 7.5 maf at its present elevation of -226 feet. The sea occupies a closed drainage basin—if there were no inflows to maintain lake levels, its waters would evaporate as did those of prehistoric Lake Cahuilla. The area's average annual precipitation is 3 inches or less, while average annual evaporation is in excess of 5 feet. The sea receives over 1 maf of inflow annually, primarily from

A false-color infrared satellite photo of the Salton Sea (January 1998 Landsat 5). The irrigated areas in Imperial Valley are clearly visible to the south of the sea, as are the Algodones Dunes to the southeast. The City of Mexicali and irrigated acreage in the Mexicali Valley can also be seen.

agricultural drainage. The largest sources of inflow (about 80 percent of the total) are the New and Alamo Rivers which drain agricultural lands in the Mexicali and Imperial Valleys and flow into the sea's southern end. The New River also receives untreated and minimally treated wastewater flows from the Mexicali area; monitoring results generally indicate that pollution associated with wastewater discharges does not reach the sea because of its distance from the Mexican border.

In 1924, President Coolidge issued an executive order withdrawing seabed lands lying below elevation -244 feet for the purpose of receiving agricultural drainage water. That order was expanded in 1928 to lands below elevation -220 feet. The sea supports water-based recreational activities, and has had a popular corvina fishery. During the 1950s, the highest per capita sport fishing catches in California were from the Salton Sea. Over the years, concerns about the sea's salinity have been voiced in the context of maintaining the recreational fishery that was established with introduced species able to tolerate high salinities.

The sea also provides important wintering habitat for many species of migratory waterfowl and shorebirds, including some species whose diets are based exclusively on the fish in the sea. Wetlands near the sea and adjoining cultivated agricultural lands offer the avian population a mix of habitat types and food sources. An area at the sea's south end was established as a national wildlife refuge in 1930, although most of that area is now under water as a result of the sea's rising elevation. Some of the 380 bird species wintering in the area include pelicans, herons, egrets, cranes, cormorants, ibises, ducks, grebes, falcons, plovers, avocets, sandpipers, and gulls. The Salton Sea is considered to be a major stopover point for birds migrating on the Pacific Flyway, and has one of the highest levels of bird diversity of refuges in the federal system.

Historically, salinity has been the water quality constituent of most concern at the sea. Present levels are about 44,000 mg/L TDS (seawater is about 35,000 mg/L TDS). This high level of salinity reflects long- term evaporation and concentration of salts found in its inflow. Selenium has been a more recent constituent of interest, due to its implications for

Roadrunners are one of the bird species found year-round in the Salton Sea area.

aquatic species. Although selenium levels in the water column in the sea are less than the federal criterion of 5*u*g/L, this concentration can be exceeded in seabed sediment and in influent agricultural drainage water. Agricultural drain flows also contribute significant nutrient loading to the sea, which supports large algal blooms at some times of the year. These algal blooms have contributed to odor problems and low dissolved oxygen levels in some areas of the sea.

Over the years, USBR and others have considered potential solutions to stabilize the sea's salinity and elevation. Most recently, the Salton Sea Authority (a joint powers authority consisting of Riverside and Imperial Counties, IID, and CVWD) and others have been performing appraisal level evaluations of some of the frequently suggested alternatives. Categories of alternatives considered include:

- Diking off part(s) of the sea to create evaporation pond(s) adjoining the primary water body. This approach would divert part of the sea's water into managed impoundments, where the water would be concentrated into a brine and the salts would eventually be removed. The facilities would be sized to maintain a primary waterbody at some desired salinity concentration and elevation. The desired salinity concentration would probably be near that of ocean water (or slightly greater) to maintain the recreational fishery.
- Pumping Salton Sea water and exporting it to some other location. Possible discharge locations include nearby dry desert lakebeds (to create evaporation ponds), evaporation ponds to be constructed near the sea, the Gulf of California, or the Laguna Salada in Mexico.
- Building treatment facilities (such as a desalting plant) to remove salts from inflows to the sea.
- Importing fresh water to the sea. The most apparent source would be the Colorado River, but only in years when flood control releases were being made in excess of U.S. needs.

Maintaining a viable Salton Sea has several water management implications. First will be the actions needed to stabilize the sea's salinity in the near-term, such as the Authority's diking proposal. Eventually, a long-term solution will need to be developed. A wide range of costs has been mentioned for a long-term solution, including amounts in the billion-dollar range. Some of the possible long-term solutions suggested would entail constructing facilities in Mexico, bringing a greater level of complexity to their implementation. Other water management programs in the region, such as proposals to transfer conserved agricultural water supplies, will have to be evaluated in terms of their impacts on the sea. Recent proposals to desalt water in the Alamo or New Rivers and to transport that water in the Colorado River Aqueduct to the South Coast for urban water supply have raised concerns about maintaining the sea's environmental productivity. Such proposals might be implemented as part of the second phase of CRB's draft 4.4 Plan. (In 1997, CVWD filed an application with the SWRCB for water rights to storm water flows and drainage flows in the Whitewater River at the sea's northern end. MWDSC made a similar filing for agricultural drainage flowing into the sea's southern end.)

Congressional legislation introduced in 1998 would authorize expenditure of federal funds for a multi-year study of the sea's resources and potential solutions for managing its salinity.

Coachella Valley Groundwater Overdraft

Most PSAs within the Colorado River Region have sufficient water to meet future water needs, with the exception of Coachella Valley. Groundwater overdraft is occurring in the upper (urbanized) part of the valley; DWA and CVWD have been managing extractions in that basin to minimize future overdraft. Imported surface water at the upper end of the valley has provided a source of recharge water.

Groundwater overdraft is also occurring in the

Groundwater recharge ponds at Windy Point, to the east of San Gorgonio Pass in Riverside County. Water from the Whitewater River, along with Colorado River Aqueduct supplies exchanged for SWP deliveries of CVWD and DWA, provides recharge in the upper Coachella Valley area.

lower (agricultural) portion of the valley, an area that roughly coincides with CVWD's Improvement District No.1. CVWD estimates that actual 1995 water use within the district was about 520 taf, part of which was supplied by overdrafting the groundwater basin. (Irrigators in the lower valley are supplied by surface water from the Coachella Canal and by groundwater.) The district is in the process of preparing a groundwater management plan for the lower valley, and has considered alternatives including basin adjudication, water conservation, water recycling, and direct or in lieu recharge with water imported from the Colorado River or from the SWP. CVWD estimates that overdraft in the lower valley is about 170 taf/yr. Overdraft calculated from Bulletin 160-98 water budgets is 70 taf/yr for the upper and lower valley combined.

Lower Colorado River Environmental Water Issues

Listed fish species on the mainstem of the Colorado River include the Colorado squawfish, razorback sucker, humpback chub, and bonytail chub. Restoration actions to protect these fish may affect reservoir operation and streamflow in the mainstem and tributaries. Other species of concern in the basin include the bald eagle, Yuma clapper rail, belted kingfisher, southwestern willow flycatcher, and Kanab ambersnail.

In 1993, USFWS published a draft recovery implementation plan for endangered fish in the upper Colorado River Basin. The draft plan included protecting instream flows, restoring habitat, reducing impacts of introduced fish and sportsfish management, conserving genetic integrity, monitoring habitat and populations, and increasing public awareness of the role and importance of native fish.

Problems facing native fish in the mainstem Colorado River and its tributaries will not be easily resolved. For example, two fish species in most danger of extinction, the bonytail chub and razorback sucker, are not expected to survive in the wild. Although there was a commercial razorback fishery until 1950, in recent years most stream and reservoir fisheries in the basin have been managed for non-native fish. These management practices have harmed residual populations of natives. Many native fish are readily propagated in hatcheries, and thus recovery programs include captive broodstock programs to maintain the species. Reestablishing wild populations from hatchery stocks will have to be managed in concert with programs to manage river habitat. For example, although 15 million juvenile razorback suckers were planted in Arizona streams from 1981-90, the majority of these planted fish were likely eaten by introduced predators. In 1994, the states of Colorado, Wyoming, and Utah reached an agreement with USFWS on protocols for stocking non-native fish in the Upper Basin—stocking protocols consistent with native fish recovery efforts. In a program which began in 1989, USBR and other state and federal agencies have cooperated to capture, rear, and successfully reintroduce about 15,000 razorback sucker larvae in Lake Mojave.

Instream flows in the mainstem and key tributaries are being evaluated as components of native fish recovery efforts. State and federal agencies are conducting studies to estimate base flow and flushing flow needs for listed and sensitive species in various river

reaches. An example of flushing flow evaluation occurred in the spring of 1996 when releases from Glen Canyon Dam were increased for several days to attempt to redistribute sediment and create shallow water habitat in the mainstem below the dam.

In a 1997 court action involving the southwestern willow flycatcher, an environmental group filed a lawsuit against USBR and USFWS under the ESA's citizen suit provisions. The group alleged that USBR's operation of Lake Mead was endangering the flycatcher's habitat at the upper end of Lake Mead. The federal district court for Arizona ruled in favor of USBR, but the environmental group appealed the district court's decision to the Ninth Circuit Court of Appeals. The appellate court subsequently declined to hear the case, letting the district court's decision stand.

Lower Colorado River Multi-Species Conservation Program

In 1995, DOI executed partnership agreements with California, Nevada, and Arizona to develop a multi-species conservation program for ESA-listed species and many non-listed, but sensitive, species within the 100-year floodplain of the lower Colorado River, from Glen Canyon Dam downstream to the Mexican border. In 1996, a joint participation agreement was executed to provide funding for the program. USFWS has designated the LCRMSCP steering committee as an ecosystem conservation and recovery implementation team pursuant to ESA. The steering committee is composed of representatives from the three states, DOI, Indian tribes, water agencies, power agencies, environmental organizations, and others.

The conservation program will work toward recovery of listed and sensitive species while providing for current and future use of Colorado River water and power resources, and includes USBR's Colorado River operations and maintenance actions for the lower river. Over 100 species will be considered in the program, including the southwestern willow flycatcher, Yuma clapper rail, and the four listed fish species mentioned above. Developing the program is estimated to take three years. Costs of program development and implementation of selected interim conservation measures, estimated at $4.5 million, are to be equally split between DOI and the nonfederal partners.

USBR initiated a formal Section 7 consultation process with USFWS, who issued a five-year biological opinion on USBR operation and maintenance activities from Lake Mead to the southerly international boundary with Mexico in 1997. USBR has estimated that the cost of implementing the biological opinion's reasonable and prudent alternatives and measures could be as high as $26 million.

The steering committee is currently participating in funding several interim conservation measures. These include a razorback sucker recovery program at Lake Mojave, restoration of Deer Island near Parker, Arizona, and a "Bring Back the Natives" program sponsored by the National Fish and Wildlife Foundation.

Water Management Options for the Colorado River Region

The only forecasted shortages within the Colorado River region are those resulting from groundwater overdraft in Coachella Valley. Implementing the draft CRB 4.4 Plan entails developing options in the Colorado River Region to keep MWDSC's Colorado River Aqueduct flowing at its full capacity, as described earlier. The reduction in California's use of Colorado River water to the basic 4.4 maf apportionment reduces the supply available to California by as much as 0.9 maf/yr.

Table 9-21 shows a list of options for the region, and the results of an initial screening of the options. The retained options were evaluated (Table 9A-3 in Appendix 9A) based on a set of fixed criteria discussed in Chapter 6. These options could be used for implementing the draft CRB 4.4 Plan and for reducing the Colorado River Region's groundwater overdraft.

Water Conservation

Urban. Urban water demand forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. All urban conservation options were retained. Reducing outdoor water use to 0.8 ET_o in new development would attain 9 taf/yr of depletion reductions, while extending this measure to include existing development would reduce depletions by 18 taf/yr. Reducing indoor water use to 60 gpcd and 55 gpcd would reduce depletions by 2 and 3 taf/yr, respectively. Reducing commercial, institutional, and industrial water use by 3 percent and 5 percent would save 1 and 2 taf/yr, respectively. Reducing distribution system losses to 7 and 5 percent would result in 9 and 13 taf/yr of depletion reductions, respectively.

Agricultural. The 2020 agricultural water demand forecasts assume that EWMPs are in place. As with

TABLE 9-21

Colorado River Region List of Water Management Options

Option	*Retain or Defer*	*Reason for Deferral*
Conservation		
Urban		
Outdoor Water Use to $0.8ET_o$	Retain	
Indoor Water Use	Retain	
Interior CII Water Use	Retain	
Distribution System Losses	Retain	
Agricultural		
Seasonal Application Efficiency Improvements	Retain	
Flexible Water Delivery	Retain	
Canal Lining and Piping	Retain	
Tailwater Recovery	Retain	
Modify Existing Reservoirs/Operations		
Reoperating Colorado River System Reservoirs	Defer	Concurrence of USBR and other basin states not yet obtained.
New Reservoirs/Conveyance Facilities		
Additional Conveyance Capacity for Colorado River Water	Defer	California's current excess use of Colorado River water.
Groundwater/Conjunctive Use		
Groundwater Recharge Project at East Mesa	Defer	Scoped as one-time program.
Water Marketing		
Interstate banking	Retain	
Intrastate banking and transfers	Retain	
Land fallowing program	Retain	
Water Recycling		
Water recycling options	Defer	Water recycling options would not generate new water supply.
Desalting		
Brackish Groundwater		
—	—	—
Seawater		
—	—	—
Other Local Options		
Desalting local drainage water	Defer	To be evaluated in phase 2 of draft CRB 4.4 Plan.
Lining All American Canal	Retain	
Additional Lining of Coachella Canal	Retain	
Weather Modification	Defer	Complicated by interstate management issues.
Statewide Options		
—	—	See Chapter 6.

TABLE 9-22
Potential Colorado River Water Conservation Programs

Program	*Participants*	*Comments/Status*	*Estimated Savings*
Lining of All American Canal	USBR, IID CVWD, MWDSC	Authorized by PL 100-675. Final EIS/EIR published. Preferred alternative is constructing a new, lined parallel canal.	Not implemented yet. Potential of 67.7 taf/yr savings.
Agreement for a long-term transfer of up to 200 taf/yr	IID, SDCWA	SCDWA and IID executed an agreement in 1998. Initial agreement negotiated for wheeling water in MWDSC's Colorado Aqueduct. EIR/EIS not yet prepared.	Not implemented yet - up to 200 taf/yr savings.
Additional lining of Coachella Canal	USBR, others	Authorized by PL 100-675. Draft EIR/EIS issued.	Not implemented yet. Potential of 25.68 taf/yr savings.

the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Improving seasonal application efficiency to 80 percent from the base of 73 percent could reduce depletions by 50 taf/yr. Improving flexible water delivery, canal lining (on-farm and distribution system), and tailwater recovery systems could together realize 140 taf/yr in depletion reductions. However, the ability to implement conservation options that would reduce the amount of fresh water inflow to the Salton Sea must be evaluated on a project-specific basis. Goals for preservation of the sea's environmental resources may limit the extent of feasible conservation measures.

Land Fallowing. Programs such as the Palo Verde test land fallowing program could be implemented to provide water for transfer to urban areas in the South Coast Region during drought periods. In 1992, MWDSC conducted a two-year land fallowing test program with PVID. Under this program, growers in PVID fallowed about 20,000 acres of land. The saved water, about 93 taf/yr, was stored in Lower Colorado River reservoirs for future use by MWDSC (the water was later released when Colorado River flood control releases were made from Lake Mead). MWDSC paid each grower $1,240 per fallowed acre, making the cost of the water to MWDSC about $135/af. Similar programs could be implemented in the future to provide about 100 taf/yr during drought years. Future land fallowing agreements would need to consider the availability of storage for the transferred water.

Potential Sources of Water for Intrastate Marketing

The ability to market conserved water has already been demonstrated in the region. Table 9-22 summarizes some potential sources of water for intrastate transfers. Such transfers could make up some of the shortages in the South Coast Region resulting from California reducing its use to California's basic apportionment of 4.4 maf.

Construction of additional conveyance capacity from the Colorado River Region to the South Coast Region has been a recent subject of discussion. Proposition 204 provides funding for a feasibility study of a new conveyance facility from the Colorado River to the South Coast Region. Conveyance facilities mentioned include a new aqueduct from the Imperial Valley area to San Diego (on the United States side of the border), as well as San Diego's participation in enlarging the existing aqueduct serving Tijuana, Mexico. Tijuana's situation is similar to San Diego's, in that Tijuana is seeking to expand its urban supplies by negotiating transfer of agricultural water from the Mexicali Valley. Figure 9-6 is a map of the U.S. - Mexican border area, showing the area's larger water facilities. A preliminary engineering study of constructing a new canal from Imperial Valley to SDCWA's service area has been prepared for SDCWA. Additional work, including geotechnical exploration and environmental studies, would be needed to evaluate the project's feasibility. The preliminary study highlighted the need to evaluate desalting the water that the aqueduct would supply, to enable San Diego's continued reliance on a high level of water recycling. New conveyance facilities from the Colorado River Region to the South Coast Region have been deferred from evaluation in Bulletin 160-98 because it does not appear that they would be constructed within the Bulletin's planning horizon, given the other basin states' concerns about California's

FIGURE 9-6

U.S.-Mexican Border Region

use of Colorado River water and the international complexities associated with a joint project with Mexican agencies.

SDCWA and IID have been negotiating a potential transfer of water saved due to extraordinary conservation measures within IID. The agencies initially executed a 1995 MOU concerning negotiation of a transfer agreement, followed by 1998 execution of an agreement specifying the transfer's terms and conditions. The agreement has a minimum 45-year term, and can be extended for an additional 30 years. An initial transfer of 20 taf would begin in 1999, with the annual quantity of transferred water increasing to a maximum of 200 taf. In order to transfer the acquired water, SDCWA (a member agency of MWDSC) has negotiated an initial wheeling agreement with MWDSC for use of capacity in MWDSC's Colorado River Aqueduct. Environmental documentation for the transfer is pending.

Past conservation projects in the region have included land fallowing, canal lining, distribution system reservoir and spill interceptor canal construction, and irrigation distribution system improvements. Some proposed projects to recover canal seepage include:

- ***Lining part of the All American Canal.*** Public Law 100-675 authorized the Secretary of the Interior to line the canal or to otherwise recover canal seepage, using construction funds from PVID, IID, CVWD, or MWDSC. USBR's environmental documentation evaluated a parallel canal alternative, several in-place lining alternatives, and a well field alternative, and concluded that the preferred alternative was the construction of a concrete-lined canal parallel to 23 miles of the existing canal. The parallel canal alternative has the potential to conserve an estimated 67.7 taf annually of Colorado River water. Recently, the well field alternative has been reevaluated and found to be infeasible. The well field alternative, although less expensive than canal lining, has been set aside because of international concerns about groundwater extraction near the border.
- ***Lining the Remaining Section of the Coachella Canal.*** This project would involve lining the remaining 33.4 miles of the Coachella Canal, which loses about 32.4 taf/yr through seepage. Four alternatives that have been identified are conventional lining, underwater lining, parallel canal, and no action. It is estimated that the preferred alternative, conventional lining, would conserve 25.7 taf/yr.

Intrastate Groundwater Recharge or Banking

IID has proposed a groundwater recharge project at East Mesa in the Imperial Valley. The proposed recharge project would divert a portion of flood control releases from Lake Mead to a recharge site or sites located along the alignment of the old, unlined Coachella Canal. (The old canal was abandoned when an adjacent lined canal was constructed.) IID estimates that up to 20 taf could be recharged in 1998. IID prepared a mitigated negative declaration for a one-time program in 1998, when flood control releases are occurring. Since Colorado River flood control releases have historically been infrequent, future water supply for such a recharge program would be available only occasionally. This option was scoped as a one-time project and is not considered as a 2020-level option in Bulletin 160-98.

MWDSC has executed agreements with three entities to study the potential of groundwater banking arrangements that would involve storing surplus Colorado River water, when available, in groundwater basins near its Colorado River Aqueduct. The water would be withdrawn for use in the South Coast in drought years. An agreement with Cadiz Land Company covered a potential project that would entail constructing a 35-mile pipeline from the Cadiz Valley/Fenner Valley area, and diverting up to 100 taf/yr of surplus Colorado River water to storage. Estimated available groundwater storage capacity is 500 taf, with drought year withdrawal capability of 100 taf. This arrangement could additionally have a marketing component; perhaps 20 to 30 taf/yr of recharge in Cadiz and Fenner Valleys could be blended with Colorado River water and delivered to the South Coast Region. An agreement with Catellus Development Company covered a potential groundwater storage site in the Mojave Desert with an estimated capacity of 600 taf. The withdrawal capability of this site is estimated at about 150 taf/yr. A third agreement was with CVWD. CVWD is presently performing pilot studies to estimate recharge and withdrawal capabilities in the lower valley. (MWDSC and CVWD have already been evaluating increased recharge at the upper end of the valley, in the Whitewater River drainage basin.)

Technical studies of the feasibility of these projects remain to be completed, and environmental documentation has not yet been prepared. It appears likely that at least 100 taf/yr of drought year supplies could be provided through this group of potential storage sites.

Interstate Banking/Conservation

Under an existing agreement between MWDSC and the Central Arizona Water Conservation District, MWDSC can store a limited amount of Colorado River water in Arizona for future use. The Southern Nevada Water Authority is also participating in the program. The agreement stipulates that MWDSC and SNWA can store up to 300 taf in central Arizona through the year 2000. As of 1997, MWDSC has placed 89 taf in storage and SNWA has placed 50 taf in storage, for a total of 139 taf. About 90 percent of the stored water can be recovered, contingent upon the declaration of a surplus. When MWDSC is able to draw on this source, it can divert up to a maximum of 15 taf in any one month. The stored water would be made available by Arizona foregoing the use of part of its normal supply from Central Arizona Project. MWDSC plans to recover the stored water at times in the future when its Colorado River Aqueduct diversions may be limited. Like the East Mesa project described in the preceding section, this interstate project was a one-time action, and is not considered as a 2020-level option in Bulletin 160-98.

In its 1996 session, the Arizona Legislature enacted legislation establishing the Arizona Water Banking Authority. The Authority is authorized to purchase unused Colorado River water and to store it in groundwater basins to meet future needs. Conveyance to storage areas is provided by the Central Arizona Project. The legislation further provided that the Authority may enter into agreements with California and Nevada agencies to bank water in Arizona basins, with the following limitations:

- Regulations governing interstate banking would need to be promulgated by the Secretary of the Interior.
- The Arizona Department of Water Resources finds that DOI's regulations adequately protect Arizona's rights to Colorado River water.
- The ability to bank interstate water would be subordinate to banking of water to supply Arizona needs.
- Interstate banking would be precluded in years when Arizona is using its full apportionment of 2.8 maf (including water being delivered to Arizona for banking by Arizona agencies), unless surplus conditions were declared for the river system.
- Interstate withdrawals from the bank are limited to 100 taf/yr, although there is no statutory limitation on annual deposits.

Under this legislation, future interstate banking in Arizona would have a maximum annual yield of 100 taf. However, Arizona may effectively limit withdrawals in drought years by declining to decrease its diversions of surface water to allow recovery of the banked water. USBR released draft rules and regulations for the interstate banking program for public comment in December 1997, and is presently reviewing the public comments.

Reoperating Colorado River System Reservoirs

Member agencies represented by the CRB have discussed proposing reservoir operating criteria to the Secretary of the Interior that would benefit California while protecting the apportionments of the other basin states and satisfying Mexican treaty obligations. Such criteria would also constitute part of the package of actions for California to transition its use of river water from current levels to 4.4 maf/yr. Operations studies have evaluated specific shortage and surplus criteria for the river system, including selection of desired probabilities for water supply reliability and reservoir operating elevations.

Results of the operations studies performed by CRB and by USBR suggest that there could be minimal hydrologic risk to using reservoir reoperation—particularly as a limited-term measure to help California reduce its Colorado River use—as a water management option for this region. As described in Chapter 3, the Colorado River has a high ratio of storage capacity to average annual runoff. Projections of consumptive use for the upper basin states suggest that those states will not attain full use of their compact apportionments until after year 2060. USBR's surplus declarations to date have not adversely impacted the other states' use of their apportionments—for example, flood control releases were made both in 1997 and 1998, and are expected in 1999. The more significant impediment to implementing reoperation would be concerns of the other basin states about impacts of an extended period of reoperation on future shortages, considering the river's variable year to year runoff.

For Bulletin 160-98, reservoir reoperation is not evaluated as a water management option and no numerical evaluation is made, since consensus of USBR and the basin states has not yet been obtained.

Weather Modification

A fundamental management issue associated with

Colorado River water supplies is the apparent overstatement of the Compact apportionment relative to the river's historical hydrology. There have been proposals over the years to augment the river's base flow to provide additional supplies. For example, USBR had developed a proposed pilot program in 1993 to evaluate cloud seeding potential in the Upper Basin. The State of Colorado did not favor moving ahead with this program.

Weather modification has recently been raised again as part of a possible menu of options to resolve California's use in excess of the 4.4 maf basic apportionment, although no specific proposals have been made. In concept, this option would entail cloud seeding in the Upper Basin to increase runoff, and might yield a 5 percent increase in base flow from the area seeded. Large-scale weather modification projects are typically difficult to implement due to institutional and third-party concerns, and can require several years of study and testing prior to being placed in operational status. Weather modification on the Colorado River is also complicated by interstate management issues. This option has been deferred for these reasons.

Options for Coachella Valley

As discussed earlier, MWDSC has executed an agreement with CVWD to study banking of surplus Colorado River water, when available, in the lower Coachella Valley. Banking programs typically entail putting more water into the groundwater basin than is extracted, to address losses and to avoid potential localized impacts to existing basin pumpers. Over the long term this extra recharge would help stabilize groundwater basin levels. CVWD is presently in the planning stages of expanding its existing pilot recharge/extraction site in the lower valley. CVWD also plans to form a groundwater replenishment district to help manage overdraft.

MWDSC and CVWD are evaluating additional recharge possibilities in the Whitewater River drainage at the north end of the valley. Water recharged in this area could come from surplus Colorado River flows, from year-to-year purchases of SWP water or purchase of SWP entitlement, or from other water marketing arrangements that could take advantage of SWP/CRA conveyance. For example, CVWD purchased about 39 taf of water from other SWP contractors in 1996, on a one-time basis. Additional recharge possibilities in the Whitewater drainage have not yet been quantified, and are not evaluated further in Bulletin 160-98.

CVWD could, as other SWP urban water contractors are doing, participate in the permanent transfer of agricultural entitlement water provided for in the Monterey Agreement contract amendments. CVWD could also purchase water from other sources, by way of exchange with MWDSC, subject to negotiation of conveyance in the SWP and CRA. Since no specific proposals are currently pending, this option is not quantified in the Bulletin.

Statewide Options

Statewide water supply augmentation options are discussed and quantified in Chapter 6.

Options Likely to be Implemented in the Colorado River Region

Applied water shortages are forecasted to be 147 taf in average years and 158 taf in drought years. Ranking of retained water management options for the Colorado River Region is summarized in Table 9-23. Table 9-24 summarizes options that can likely be implemented by 2020 to relieve the shortages.

Options identified for this region will likely be used for reducing Coachella Valley overdraft and for managing water to benefit the South Coast Region, as called for in CRB's draft 4.4 Plan. An evaluation of these options is shown in Table 9A-3 in Appendix 9A. Bulletin 160-98 assumes that water made available by option implementation is first allocated to reduce overdraft within the region, and that remaining water is then available for use in the South Coast Region.

For readers interested in comparing Bulletin 160-98 options with the draft CRB 4.4 Plan, Table 9-25 summarizes the Bulletin's findings in a format similar to that used in the draft CRB 4.4 Plan. There is an important differences between the two documents—Bulletin 160-98 assumes that water conservation due to EWMP implementation occurs as part of base demand forecasts and not as an optional measure. Actions that may be implemented as part of phase two of the draft CRB 4.4 Plan are not shown in the table, because they have not yet been formulated and quantified.

TABLE 9-23

Options Ranking for Colorado River Region

Option[a]	*Rank*	*Cost ($/af)*	*Potential Gain (taf)*	
			Average	*Drought*
Conservation				
Urban				
Outdoor Water Use to 0.8 ET_o - New Development	M	750	9	9
Outdoor Water Use to 0.8 ET_o-New and Existing Development	M	[b]	18	18
Indoor Water Use (60 gpcd)	M	400	2	2
Indoor Water Use (55 gpcd)	M	600	3	3
Interior CII Water Use (3%)	M	500	1	1
Interior CII Water Use (5%)	M	750	2	2
Distribution System Losses (7%)	M	200	9	9
Distribution System Losses (5%)	M	300	13	13
Agricultural				
Seasonal Application Efficiency Improvements (76%)	H	100	22	22
Seasonal Application Efficiency Improvements (78%)	M	250	36	36
Seasonal Application Efficiency Improvements (80%)	M	450	50	50
Flexible Water Delivery	L	1,000	30	30
Canal Lining and Piping	L	1,200	45	45
Tailwater Recovery	H	150	65	65
Water Marketing				
Intrastate Banking	H	[b]	—	100
Interstate Banking	M	[b]	—	50
Land Fallowing Program	M	140	—	100
Other Local Options				
Lining All American Canal	H	120	68	68
Additional Lining of Coachella Canal	H	[b]	26	26
Statewide Options				
See Chapter 6.				

[a] All parts of the amounts shown for the highlighted options have been included in Table 9-24.
[b] Data not available to quantify.

TABLE 9-24

Options Likely to be Implemented by 2020 (taf)

Colorado River Region[a]

	Potential Gain (taf)	
	Average	***Drought***
Applied Water Shortage	**147**	**158**
Options Likely to be Implemented by 2020		
Conservation[b]	215	215
Modify Existing Reservoirs/Operation	—	—
New Reservoirs/Conveyance Facilities	—	—
Groundwater/Conjunctive	—	—
Water Marketing	—	250
Recycling	—	—
Desalting	—	—
Other Local Options	94	94
Statewide Options	8	7
Expected Reapplication	2	2
Total Potential Gain	**319**	**568**
Remaining Applied Water Shortage	**0**	**0**

[a] Options in excess of regional needs to reduce groundwater overdraft are available for implementing the draft CRB 4.4 Plan in South Coast Region.
[b] Water supply for San Diego CWA/IID transfer provided by agricultural conservation which could be any mix of base demand forecast EWMP implementation (210 taf) and future agricultural conservation options (190 taf).

TABLE 9-25

Future Actions Described in Bulletin 160-98

That Could be Part of Draft CRB 4.4 Plan Implementation[a]

Action	***Potential Gain (taf)***	
	Average	***Drought***
Agricultural conservation[b] to meet SDCWA/IID Agreement	200	200
Other agricultural conservation[b] from EWMP implementation and optional conservation measures	200	200
Intrastate groundwater banking from MWDSC agreements with Cadiz, Catellus, or Coachella	—	100
Interstate groundwater banking from Arizona groundwater bank	—	50
Possible future land fallowing agreement between MWDSC and PVID	—	100
Lining All American Canal	68	68
Additional lining of Coachella Canal	26	26
Statewide Options	8	7
Total	**502**	**751**

[a] Since this table shows future actions, it does not include the 1980 Coachella Canal lining, 1988 MWDSC/IID agreement, or 1992 MWDSC/CACWD/SNWA agreement described earlier in this chapter.
[b] These actions are subject to environmental review to ensure that reduced depletions will not have significant impacts to the Salton Sea.